LONG RANGE SEISMIC MEASUREMENTS

TURF

24 APRIL 1964

Prepared for

AIR FORCE TECHNICAL APPLICATIONS CENTER

Washington, D. C.

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By

UED EARTH SCIENCES DIVISION
TELEDYNE, INC.

Under

Project VELA UNIFORM

Sponsored By

ADVANCED RESEARCH PROJECTS AGENCY
Nuclear Test Detection Office
ARPA Order No. 624

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LONG RANGE SEISMIC MEASUREMENTS

TURF

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SEISMIC DATA LABORATORY REPORT NO. 130

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TABLE OF CONTENTS

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TURF

EVENT DESCRIPTION

DATE:	24 April 1964
TIME OF ORIGIN:	20:10:00.2Z
YIELD:	
MAGNITUDE:	4.95 $\pm$ 0.35
LOCATION:	

Site: Nevada Test Site

Geographic Coordinates:

Lat: $37^\circ 08' 59''$ N

Long: $116^\circ 03' 19''$ W

ENVIRONMENT:

Geologic Medium:	Alluvium
Surface Elevation:	4260 Feet
Shot Elevation:	2587 Feet
Shot Depth:	1673 Feet

COMPUTED EPICENTER: All Stations

Geographic Coordinates:

Lat: $37^\circ 04' 48''$ N

Long: $116^\circ 14' 38''$ W

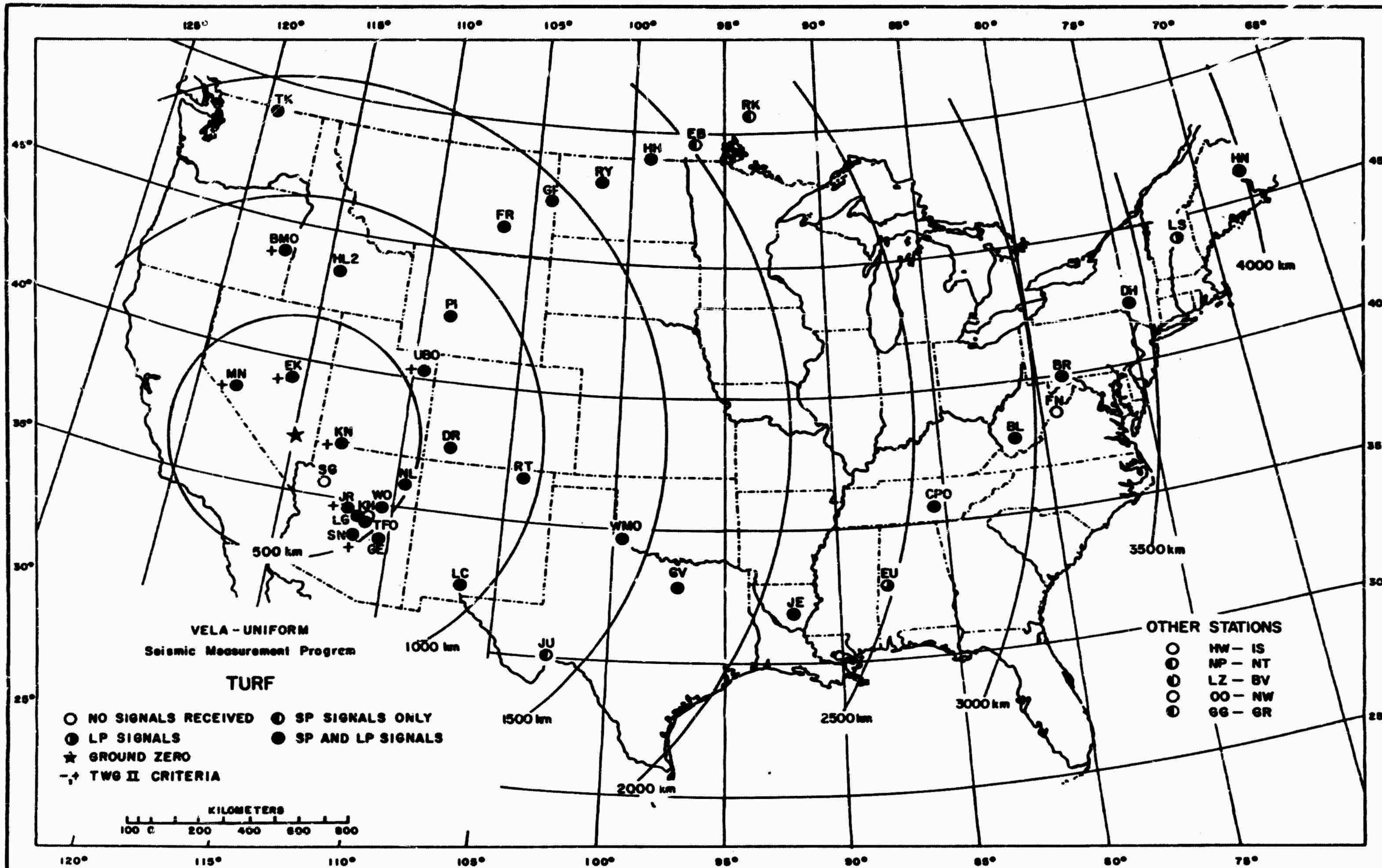
Time of Origin:	20:10:04.8Z
Depth:	44.9 km
Epicenter Shift:	18.3 km, N 246° E

Code	Station	Final							
		SPZ	SPR	SPT	LPZ	LPR	LPT	Tape	Timing
EK-NV	Eureka, Nevada	+	+	+	+	+	+	*	P
MN-NV	Mina, Nevada	+	+	+	+	+	+	*	P
KN-UT	Kanab, Utah	+	+	+	+	+	+	*	P
SG-AZ	Seligman, Arizona	I	I	I	I	I	I		
JR-AZ	Jerome, Arizona	+	+	+	+	+	+	*	P
LG-AZ	Long Valley, Arizona	+	+	+	+	+	+	*	P
TFSO	Tonto Forest Observatory, Arizona	+	+	+	+	+	+	*	P
SN-AZ	Sunflower, Arizona	+	+	+	+	+	+	*	P
KH-AZ	Kohl's Ranch, Arizona	I	I	I	I	I	I		
WO-AZ	Winslow, Arizona	+	+	+	+	+	+	*	P
NL-AZ	Nazlini, Arizona	+	+	+	+	+	+	*	P
GE-AZ	Globe, Arizona	+	+	+	+	+	+	*	P
UBSO	Uinta Basin Observatory, Utah	+	+	+	+	+	-	*	P
HL2ID	Hailey, Idaho	+	+	+	+	+	+	*	P
DR-CO	Durango, Colorado	+	+	+	+	+	+	*	P
PI-WY	Pinedale, Wyoming	+	+	+	+	+	-	*	P
BMSO	Blue Mountain Observatory, Oregon	+	+	+	+	+	-	*	P
LC-NM	Las Cruces, New Mexico	+	+	+	+	+	+	*	P
RT-NM	Raton, New Mexico	+	+	+	+	+	-	*	P
FR-MA	Forsyth, Montana	+	+	+	+	+	-	*	P
TK-WA	Tonasket, Washington	+	+	+	+	+	+	*	P
GI-MA	Glendive, Montana	+	+	+	+	+	+	*	P
JU-TX	Juno, Texas	+	+	+	N	N	N	*	P
WMSO	Wichita Mountains Observatory, Oklahoma	+	+	+	+	+	+	*	P
RY-ND	Ryder, North Dakota	+	+	+	+	+	+	*	P
GV-TX	Grapevine, Texas	+	+	+	+	+	-	*	P
HH-ND	Hannah, North Dakota	+	+	+	+	+	+	*	P
EB-MT	East Braintree, Manitoba, Canada	+	+	+	-	-	-	*	P
JE-LA	Jena, Louisiana	+	+	+	+	+	+	*	P
RK-ON	Red Lake, Ontario, Canada	+	+	+	-	-	-	*	P
EU-AL	Eutaw, Alabama	-	-	-	+	+	-	*	P
CPSO	Cumberland Plateau Observatory, Tennessee	+	+	+	+	+	-	*	P
BL-WV	Beckley, West Virginia	+	+	+	+	+	+	*	P
FN-WV	Franklin, West Virginia			S E T T I N G U P					
BR-PA	Berlin, Pennsylvania	+	+	+	+	+	-	*	P
DH-NY	Delhi, New York	+	+	-	+	+	-	*	P
LS-NH	Lisbon, New Hampshire	-	-	-	+	+	+	*	P
HN-ME	Houlton, Maine	+	+	-	+	+	-	*	P
HW-IS	Kamuela, Hawaii	-	-	-	-	-	-	*	P
MB-NT	Mould Bay, Northwest Territories, Canada	+	+	-	-	-	-	*	P
LZ-BV	La Paz, Bolivia	+	?	?	-	-	-	*	P
OO-NW	Oslo, Norway	?	?	?	-	-	-	*	P
GG-GR	Grafenberg, Germany	+	?	?	-	-	-	*	P

I Inoperative
N No Instruments
P Primary Timing
\+ Signal
\- No Signal
? Questionable Signal
* Magnetic Tape Available

Station Status Report - TURF

Table 1



Recording Stations and Signals Received

Figure 1

Introduction

A long range seismic measurements (LRSM) program was established under VELA-UNIFORM to record and analyze short-period and long-period data from a planned series of U. S. underground nuclear tests. These, and other data, will be used by VELA-UNIFORM participants for studying and developing methods for distinguishing between explosive and earthquake sources.

The purpose of this report is to provide an analysis of data resulting from the TURF event from the LRSM film seismograms from operating mobile field teams; Wichita Mountain Observatory, Oklahoma (WMSO), Uinta Basin Observatory, Utah (UBSO), Blue Mountain Observatory, Oregon (BMSO), Cumberland Plateau Observatory, Tennessee (CPSO), and Tonto Forest Observatory, Arizona (TFSO); and from several experimental or temporary stations operated in connection with other research programs.

Instrumentation and Procedure

Instrumentation at each of the mobile stations consists of three-component short-period Benioff and three-component Sprengnether long-period seismographs. Data are recorded on 35 millimeter film and on one-inch 14-channel

magnetic tape. All of these stations are equipped to record WWV continuously in order to provide accurate time control. Calibration is accomplished once each day and just prior to each shot at operating settings. Specific details of the instrumentation and operating procedures for these stations are given in Field Manual, Long Range Seismic Measurement Program, Technical Report No. 63-17, which can be obtained from the Geotech Division of Teledyne Industries, Inc., Dallas, Texas. All the observatories have both long-period and short-period, three-component instrumentation in addition to their other specialized facilities.

Station site information is presented in Appendix I(A). This includes the station name and code; the geographic coordinates, distances and azimuths involved; the station elevations; and the type of instruments in use at each location.

A status report for TURF is included in Table 1, placed opposite the operations map, Figure 1. This report gives the names of 43 stations and indicates which instruments were operational and which recorded usable signals.

An explanation of the procedure for amplitude measurements used in this report is illustrated in Appendix II.

The unified magnitude (m) computations for distances less than 16° are based on AFTAC/VSC extensions of Gutenberg's Tables*. For this purpose, points from 10° to 16° were read from a curve in the Gutenberg-Richter paper and an inverse cube relationship was used to extrapolate from two to ten degrees. A table of the distance factors (B) is provided in Appendix I(B).

Appendix III quotes the Technical Working Group II (TWG II) first motion criteria, and includes diagrams illustrating the elements involved in determining a compression or rarefaction where satisfactory measurements can be made.

A standard hypocenter location program for a digital computer has been used to determine the location using data from all stations analyzed. Best-fit values of latitude, longitude, depth of focus, and time of origin are determined statistically by a least squares technique. This utilizes a Jeffreys-Bullen travel-time curve as modified by Herrin in 1961 on the basis of Pacific surface-focus recordings. Precision of the computation is limited primarily by the accuracy of arrival times, the validity of the standard travel-time

*Gutenberg, B. and Richter, C. F., Magnitude and Energy of Earthquakes, Ann. Geofis., 9 (1956), pp. 1-15.

curve, and by local velocity deviations. Since the method is based on P wave arrivals, this particular program does not make use of later phases such as pP and S in the determination of depth or location. Results are shown on the Event Description page.

Data and Results

Table 2 summarizes the measurements made of the principal phases from the TURF event. Included are the Pn and P arrival times, the maximum amplitudes (A/T) of Pn or P and Pg motion as seen on the short-period vertical instruments, and the maximum amplitudes (A/T) of the Lg phase as measured on the short-period horizontal tangential component. Long-period Love and Rayleigh wave motion are also tabulated in (A/T) form. Thirty-six stations recorded short-period signals. Long-period signals from this event were recorded by thirty-two stations.

In addition, Table 2 and Figure 2 show the unified magnitudes (m) where measurable. The average magnitude for TURF is 4.95. Six stations show compressional first motion as defined by the First Motion Criteria (TWG II).

The travel-time residuals from the Pn and P phase are within the usual limits (see Figure 3). The amplitudes of

Pn and P, Pg and Lg are shown in Figures 4, 5 and 6. Lines proportional to the inverse cube of the distance visually fitted through the observed points are shown on these graphs. Love and Rayleigh wave amplitudes are shown in Figures 7 and 8.

Attached to the report are illustrative seismograms showing the signals recorded at a number of locations. The most distant station analyzed that recorded TURF was GG-GR at a distance of 9094 kilometers.

Principal Phases
TURF
24 April 1964
20:10:00.2Z

Code	Station	Distance (km)	Inst.	Magni-fication (k) Film x 10	Phase	Observed Travel Time		Period T (sec)	Maximum Amplitude A/T	TWG II First Motion	Magni-tude (m)
						(min)	(sec)				
EK-NV	Eureka, Nevada	231	SPB	2.30	Pn		35.9	0.5	708	C	5.10
			SPS	2.30	e		38.0	0.6	1300		
			SPS	2.30	Pg		40.8	0.6	4010		
			SPB	2.30	e		50.1	0.7	3430		
			SPT	2.60	Lg			0.8	11,450		
			LPB	30.0*	LR			10.0	190		
MN-NV	Mine, Nevada	233	BPS	2.30	Pn		36.2	0.65	1180	C	5.32
			BPS	2.30	e		38.4	0.8	2517		
			SPS	2.30	Pg		40.6	0.8	4594		
			SPT	2.10	Lg			0.7	6370		
			LPT	24.3	LQ			6.5	141[illegible]		
			LPS	2.96	LR			12.0	862		
KN-UT	Kenab, Utah	287	BPS	5.34	Pn		43.2	0.6	390	C	5.08
			BPZ	5.34	e		45.4	0.5	441		
			SPS	5.34	e		46.5	0.4	236		
			SPB	5.34	Pg		(47.8)	0.6	4349		
			SPT	5.20	Lg			0.5	5256		
			LPR	34.8	LQ			10.0	424		
			LPS	3.53	LR			13.0	368		
JR-AS	Jerome, Arizona	448	SPZ	112*	Pn	01	(03.6)	0.6	61.0		4.90
			SPB	6.68	Pg	01	18.5	0.6	1180		
			SPT	7.5*	Lg			0.6	819		
			LPT	12.3	LQ			20.0	59.0		
			LPZ	10.5	LR			14.0	144		
LG-AZ	Long Valley, Arizona	509	BPB	15.1	Pn	01	11.4	0.8	53.7		5.00
			BPB	15.1	a	01	18.2	0.9	97.8		
			SPS	15.1	e	01	19.8	0.8	159		
			BPB	15.1	Pg	01	(25.8)	0.6	538		
			SPT	11.7	Lg			1.0	1318		
			LPT	14.4	LQ			10.0	228		
			LPZ	12.1	LR			14.5	218		
TFSO	Tonto Forest Observatory, Arizona	537	BPZ-71	160	Pn	01	15.1	0.4	12.3		4.44
			SPB-1	40.3	e	01	25.6	0.6	30.2		
			BPS-1	40.3	Pg	01	30.5	0.7	392		
			SPN	5.25	Lg			1.5	873		
			LPZ	7.00	LR			14.0	258		
SN-AS	Sunflower, Arizona	538	SPZ	22.3	P	01	14.8	0.7	34.6	C	4.89
			SPZ	22.3	e	01	18.1	0.6	76.5		
			SPB	22.3	Pg	01	30.4	0.7	524		
			SPT	23.2	Lg			0.8	657		
			LPT	8.75	LQ			12.0	79.1		
			LPS	9.75	LR			13.0	338		
WO AS	Winslow, Arizona	551	SPB	21.8	Pn	01	16.8	0.45	17.7		4.64
			SPS	21.8	e	01	18.2	0.6	31.3		
			SPS	21.8	e	01	30.0	0.8	131		
			SPB	21.8	Pg	01	31.6	(0.6)	(1024)		
			SPS	21.8	e	01	40.6	(1.0)	(1032)		
			BPT	21.6	Lg			0.6	(933)		
			LPZ	7.0	LR			10.0	364		
NL-AZ	Nazlini, Arizona	597	SPS	1.85*	Pn	01	22.0	(0.7)	(48.6		(5.17)
			SPS	9.80*	Pg	01	41.5	0.6	417		
			SPT	4.66*	Lg			0.8	1520		
			LPS	5.98	LR			13.0	190		
GE-AS	Globe, Arizona	626	SPB	4	Pn	01	(26.0)	(0.7)	(9.69)		(4.53)
			SPZ	40.8*	Pg	01	44.0	1.0	300		
			SPT	32.1*	Lg			1.0	218		
			LPS	11.8	LR			12.0	183		
UBSO	Uinta Basin Observatory, Utah	665	9PS-10	(35.3*)	Pn	01	33.3	0.8	(155)	C	5.69
			SPS-10	(35.3*)	Pg	01	50.8	0.7	(316)		
			LPB	30.0	LR			12.0	241		
HL2ID	Hailey, Idaho	726	SPS	35.8	Pn	01	38.2	0.6	7.20		4.47
			SPS	35.8	e	01	40.5	0.55	38.7		
			SPS	35.8	e	01	43.0	0.5	65.7		
			SPZ	35.8	Pg	02	(05.9)	0.6	222		
			SPT	34.0	Lg			0.6	311		
			LPZ	17.5	LR			12.0	86.4		
DR-CO	Durango, Colorado	733	SPS	39.7	Pn	01	39.5	0.4	18.5		4.99
			SPS	39.7	e	01	41.6	0.6	25.8		
			SPB	39.7	Pg	02	(01.8)	0.6	250		
			SPT	52.2	Lg			0.8	289		
			LPS	21.3	LR			13.0	85.0		
PI-WY	Pinedale, Wyoming	810	SPB	60.8	Pn	01	50.5	0.8	30.6		5.35
			SPS	60.8	e	01	51.8	1.0	179		
			SPS	60.8	Pg	02	14.7	0.8	225		
			BPT	64.8	Lg			1.0	(633)		
			LPS	9.90	LR			13.0	82.5		
BMSO	Blue Mountain Observatory, Oregon	862	SPS-1	600	Pn	01	56.8	0.7	14.0	C	5.10
			SPZ-1	103*	Pg	02	23.4	0.9	152		
			LPS	38.0	LR			16.0	67.0		
LC-NM	Las Cruces, New Mexico	1012	SPS	99.2	Pn	02	17.9	1.0	6.00		4.99
			SPZ	99.2	e	02	32.8	0.8	9.30		
			SPZ	99.2	Pg	02	(48.3)	1.1	123		
			SPT	105	Lg			(1.1)	(97.7)		
			LPZ	53.5	LR			16.0	86.3		

Principal Phases
TURF
24 April 1964
20:10:00.2Z

Code	Station	Distance (km)	Inst.	Magnification (k) Film x 10	Phase	Observed Travel Time (min)	Observed Travel Time (sec)	Period T (sec)	Maximum Amplitude A/T	TWG II First Motion	Magnitude (m)
RT-NM	Raton, New Mexico	1042	SPZ	167	Pn	02	(19.6)	0.5	2.20		4.58
			SPZ	167	a	02	25.6	(0.8)	7.20		
			SPZ	167	Pg	02	54.2	1.1	135		
			SPT	141	Lg			1.2	200		
			LPZ	17.1	LR			16.0	42.5		
FR-MA	Forsyth, Montana	1278	SPZ	127	P	02	(46.0)	0.9	31.0		5.64
			SPZ	127	a	02	55.4	1.0	60.9		
			SPT	135	Lg			1.0	81.4		
			LPZ	20.7	LR			13.0	56.9		
TK-WA	Tonasket, Washington	1325	SPZ	351	P	02	54.5	0.9	11.1		5.16
			SPZ	351	a	03	08.9	1.2	31.3		
			SPZ	351	a	03	24.8	1.0	22.8		
			SPT	351	Lg			1.4	80.5		
			LPZ	36.8	LR			13.0	33.6		
GI-MA	Glendive, Montana	1481	SPZ	115	P	03	11.4	1.0	22.2		5.25
			SPZ	115	a	03	21.8	1.1	38.3		
			SPZ	115	a	03	30.3	0.8	48.7		
			SPT	109	Lg			(1.0)	(64.0)		
			LPZ	8.04	LR			13.0	34.2		
JU-TX	Juno, Texas	1591	SPZ	378	P	03	(27.7)	1.1	50.4		5.21
			SPZ	378	e	03	33.8	1.2	50.9		
			SPT	386	Lg			1.2	84.5		
WMSO	Wichita Mountains Observatory, Oklahoma	1597	SPZ-8	256*	P	03	28.7	1.4	30.8		4.98
				258*	e	03	35.5	1.1	11.5		
				256*	a	04	41.8	1.2	41.9		
			SPN	304*	Lg			2.0	(182.7)		
			LPN	23.0	LQ			14.0	16.6		
			LPZ	19.0	LR			20.0	25.6		
RY-ND	Ryder, North Dakota	1700	SPZ	29.8	P	03	(44.1)	0.8	105		5.20
			SPZ	29.8	e	03	54.7	1.0	97.3		
			SPT	29.4	(Lg)			(1.6)	(139)		
			LPZ	14.8	LR			13.0	30.4		
GV-TX	Grapevine, Texas	1799	SPZ	31.5	P	03	53.8	(1.2)	(70.9)		4.75
			SPT	43.1	Lg			1.2	203		
			LPZ	20.7	LR			13.0	61.6		
HN-ND	Hannah, North Dakota	1921	SPZ	31.8	P	04	06.9	1.2	256		5.31
			SPZ	31.8	e	04	19.7	(0.6)	(108)		
			SPT	31.4	Lg			(1.6)	(187)		
			LPZ	13.5	LR			14.0	32.3		
EB-MT	East Braintree, Manitoba, Canada	2148	SPZ	214	P	04	26.5	0.8	11.2		4.05
			SPZ	214	e	04	28.5	1.0	18.7		
			SPZ	214	a	04	35.1	0.6	19.1		
			SPZ	214	a	05	09.0	0.9	15.7		
			SPZ	214	S	07	54.2	1.0	23.4		
			SPT	200	(Lg)			2.0	65.6		
JS-LA	Jena, Louisiana	2281	SPZ	50.1	(P)	04	41.6	(0.4)	(80.0)		(4.95)
			SPT	50.8	Lg			(1.6)	(172)		
			LPZ	9.95	LR			13.5	85.4		
RK-ON	Red Lake, Ontario, Canada	2338	SPZ	200	P	04	45.1	1.1	171		5.33
			SPZ	200	e	04	49.0	0.8	(59.7)		
			SPZ	200	e	04	51.0	0.9	77.8		
			SPT	199	Lg			1.4	36.7		
EU-AL	Eutaw, Alabama	2608	LPZ	8.30	LR			15.0	37.9		
CPSO	Cumberland Plateau Observatory, Tennessee	2730	SPZ-8	310	P	05	21.8	0.9	17.2		4.65
			SPZ-8	310	e	05	23.2	(0.8)	(19.9)		
			SPZ-8	310	e	05	27.2	0.8	(12.5)		
			SPZ-8	310	a	06	58.8	(1.4)	(17.7)		
			SPN	340	Lg			1.1	23.0		
			LPZ	15.0	LR			13.0	58.7		
BL-WV	Beckley, West Virginia	3057	SPZ	56.1	P	05	48.7	(0.6)	(6.40)		(4.36)
			SPT	53.8	Lg			1.6	43.3		
			LPZ	10.7	LR			(20.0)	(24.1)		
BR-PA	Berlin, Pennsylvania	3236	SPZ	137	P	06	03.2	1.1	22.5		4.95
			LPZ	21.2	LR			12.0	131		
DH-NY	Delhi, New York	3542	SPZ	52.8	P	06	27.3	(0.9)	(7.96)		(4.60)
			LPZ	18.0	LR			15.0	52.9		
LS-NH	Lisbon, New Hampshire	3767	LPT	17.4	LQ			18.0	10.9		
			LPZ	17.7	LR			13.0	77.5		
HN-ME	Houlton, Maine	4063	SPZ	147	P	07	07.6	1.0	29.0		5.01
			LPZ	14.3	LR			16.0	22.6		
MB-NT	Mould Bay, Northwest Territories, Canada	4382	SPZ	228	P	07	29.8	1.0	30.7		4.89
			SPZ	228	e	07	44.8	0.7	10.8		
			SPZ	228	a	08	59.1	1.5	15.0		
LZ-BV	La Paz, Bolivia	7728	SPZ-6	178	P	11	(11.4)	(1.1)	(6.00)		(4.73)
GG-GR	Grafenberg, Germany	9094	SPZ-3	73.1	P	12	(22.4)	(0.8)	(12.5)		(4.98)

A/T mu/sec
C Compressional
( ) Doubtful Values or Phases
* Measurements Made from Playouts

Principal Phases - TURF

Table 2 - Page 2

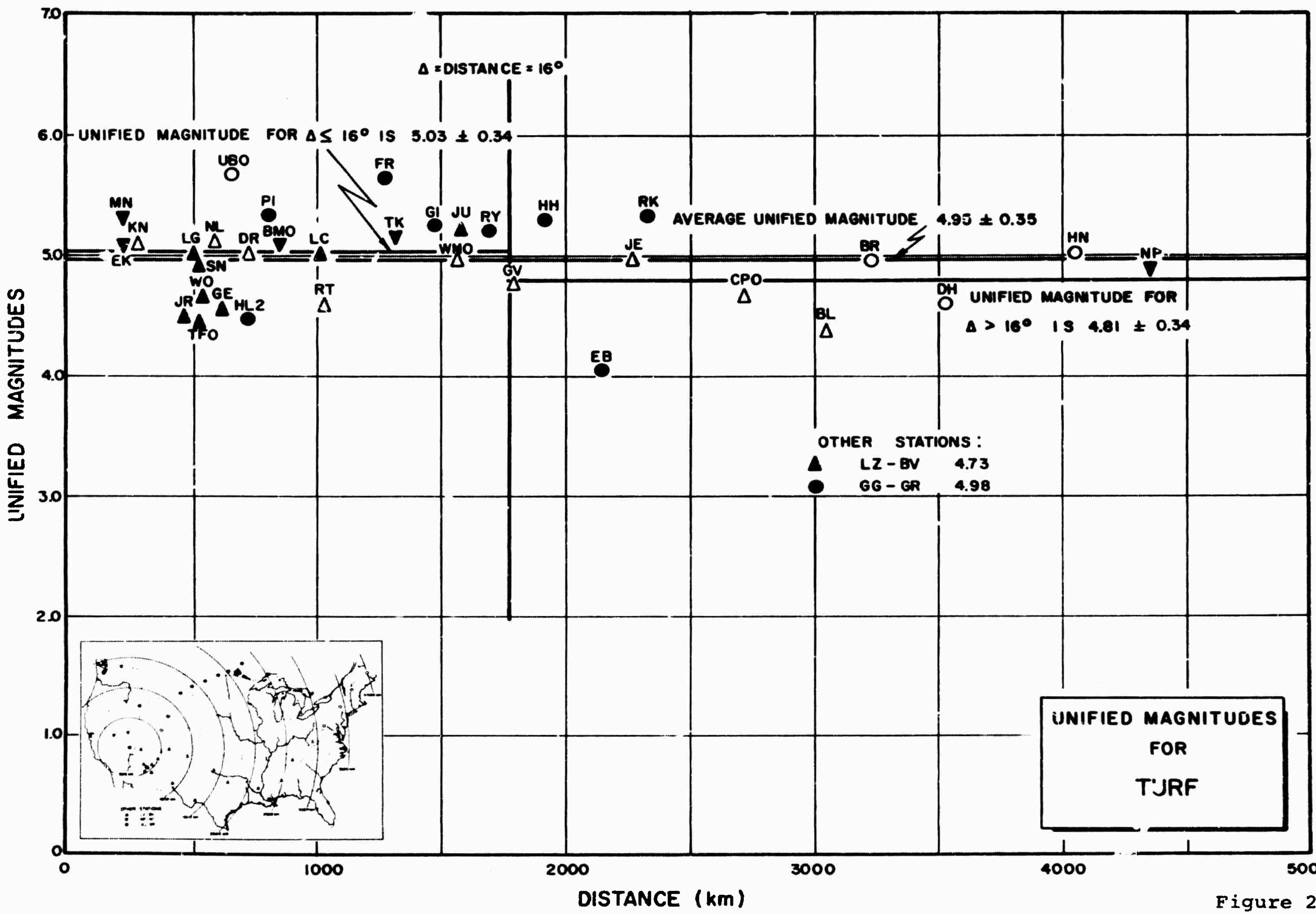

UNIFIED MAGNITUDES
DISTANCE (km)
0
1000
2000
3000
4000
5000
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
Δ = DISTANCE = 16°
UNIFIED MAGNITUDE FOR Δ ≤ 16° IS 5.03 ± 0.34
AVERAGE UNIFIED MAGNITUDE 4.95 ± 0.35
UNIFIED MAGNITUDE FOR
Δ > 16° IS 4.81 ± 0.34
MN
KN
EK
LG
NL
SN
WO
JR
GE
TFO
HL2
DR
BMO
PI
UBO
LC
RT
FR
TK
GI
JU
RY
WMO
GV
HH
RK
JE
EB
CPO
BL
BR
DH
HN
NP
OTHER STATIONS:
LZ - BV 4.73
GG - GR 4.98
UNIFIED MAGNITUDES
FOR
TURF

Figure 2

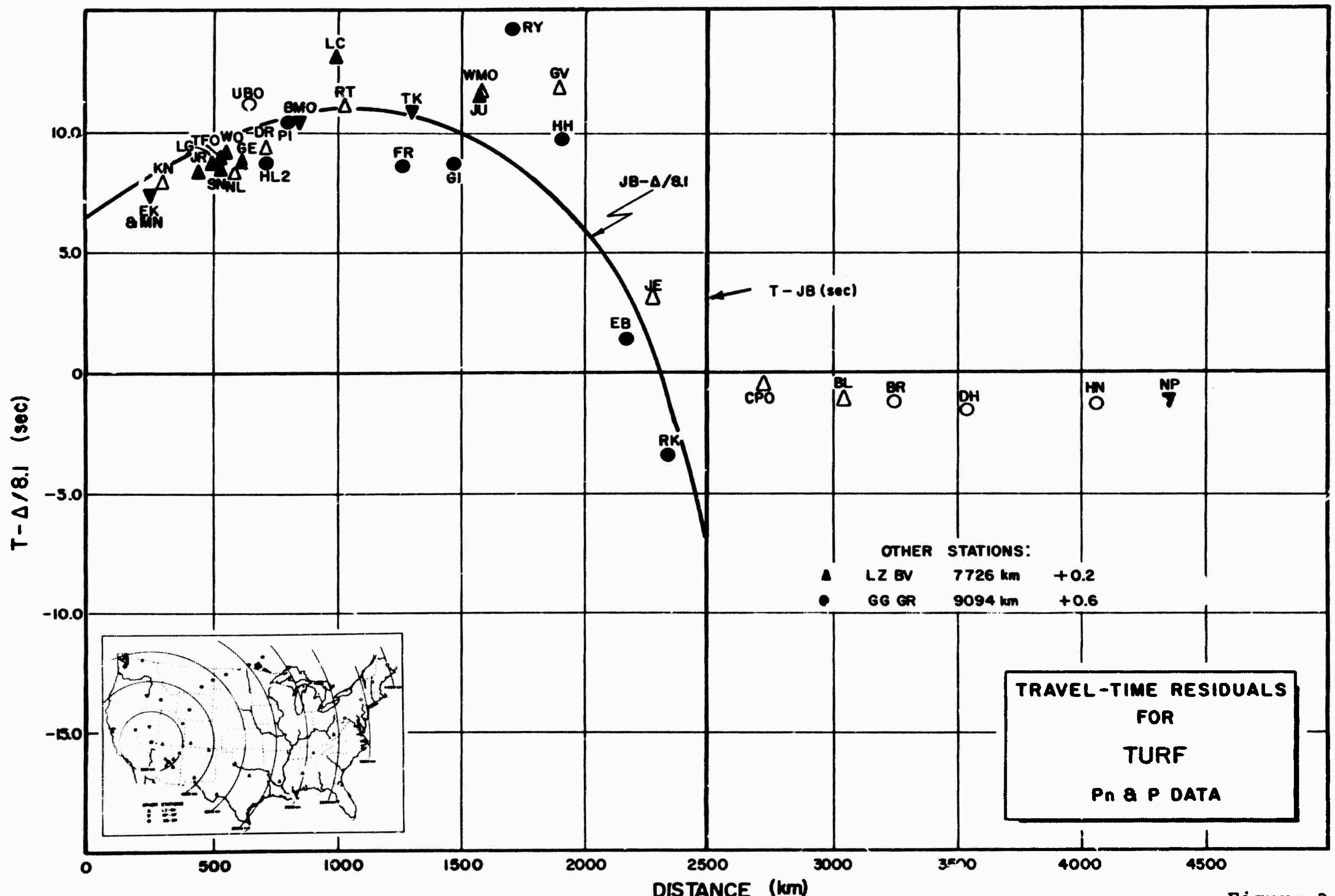
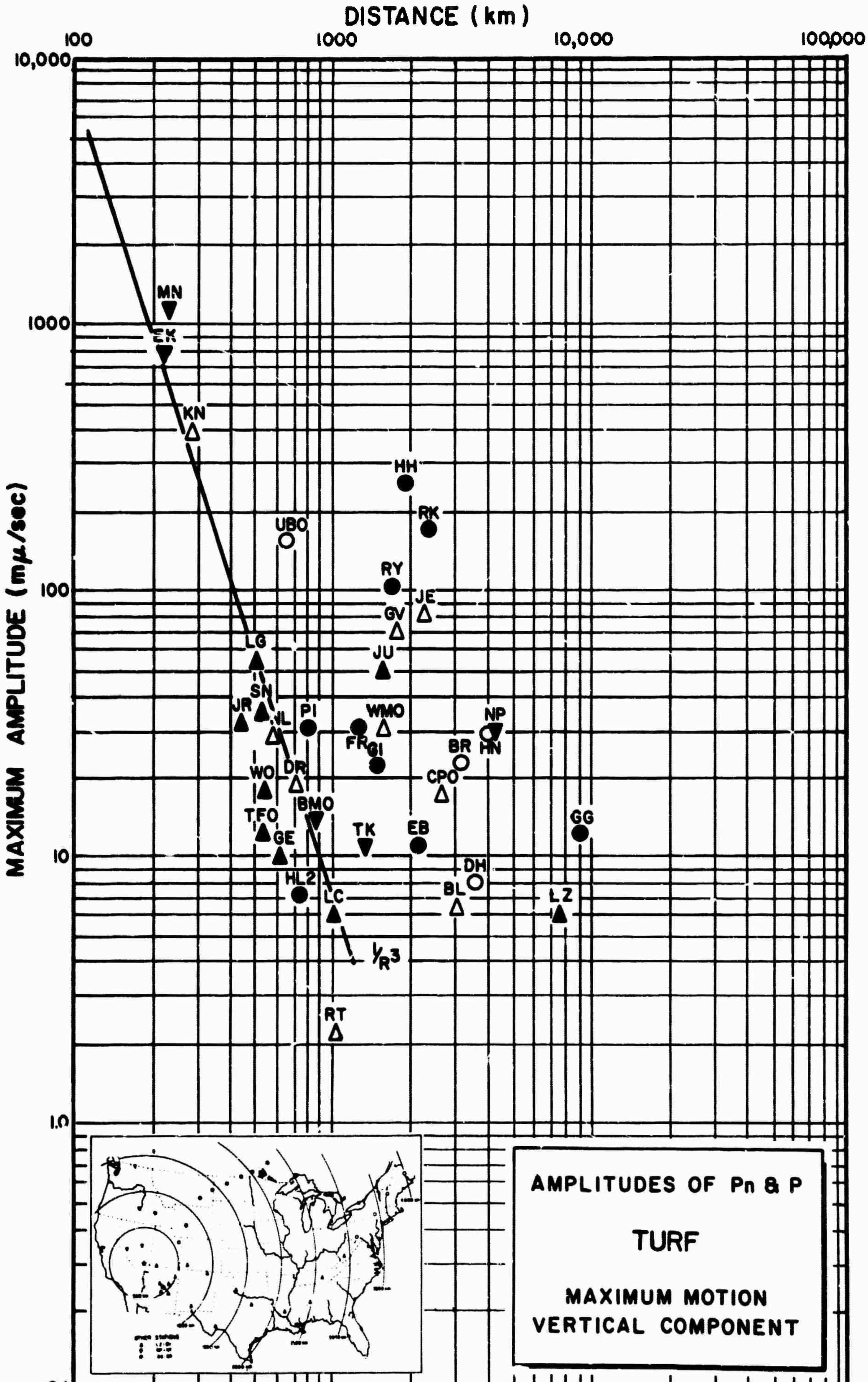

TRAVEL-TIME RESIDUALS
FOR
TURF
Pn & P DATA
OTHER STATIONS:
LZ BV 7726 km +0.2
GG GR 9094 km +0.6
JB-Δ/8.1
T - JB (sec)
T-Δ/8.1 (sec)
DISTANCE (km)
10.0
5.0
0
-5.0
-10.0
-15.0
0
500
1000
1500
2000
2500
3000
4000
4500
RY
LC
WMO
GV
UBO
RT
TK
BMO
JU
HH
DR
PI
WO
TFO
LG
JR
GE
KN
SN
NL
HL2
FR
GI
EK
& MN
JE
EB
CPO
BL
BR
DH
HN
NP
RK

Figure 3



DISTANCE (km)
100
1000
10,000
100,000
10,000
1000
100
10
1.0
0.1
MAXIMUM AMPLITUDE (mμ/sec)
MN
EK
KN
HH
RK
UBO
RY
JE
GV
LG
JU
SN
JR
NL
PI
WMO
NP
FR
GI
BR
HN
WO
DR
CPO
TFO
BMO
GE
TK
EB
GG
HL2
DH
LC
BL
LZ
$1/R^3$
RT
AMPLITUDES OF Pn & P
TURF
MAXIMUM MOTION
VERTICAL COMPONENT

Figure 4

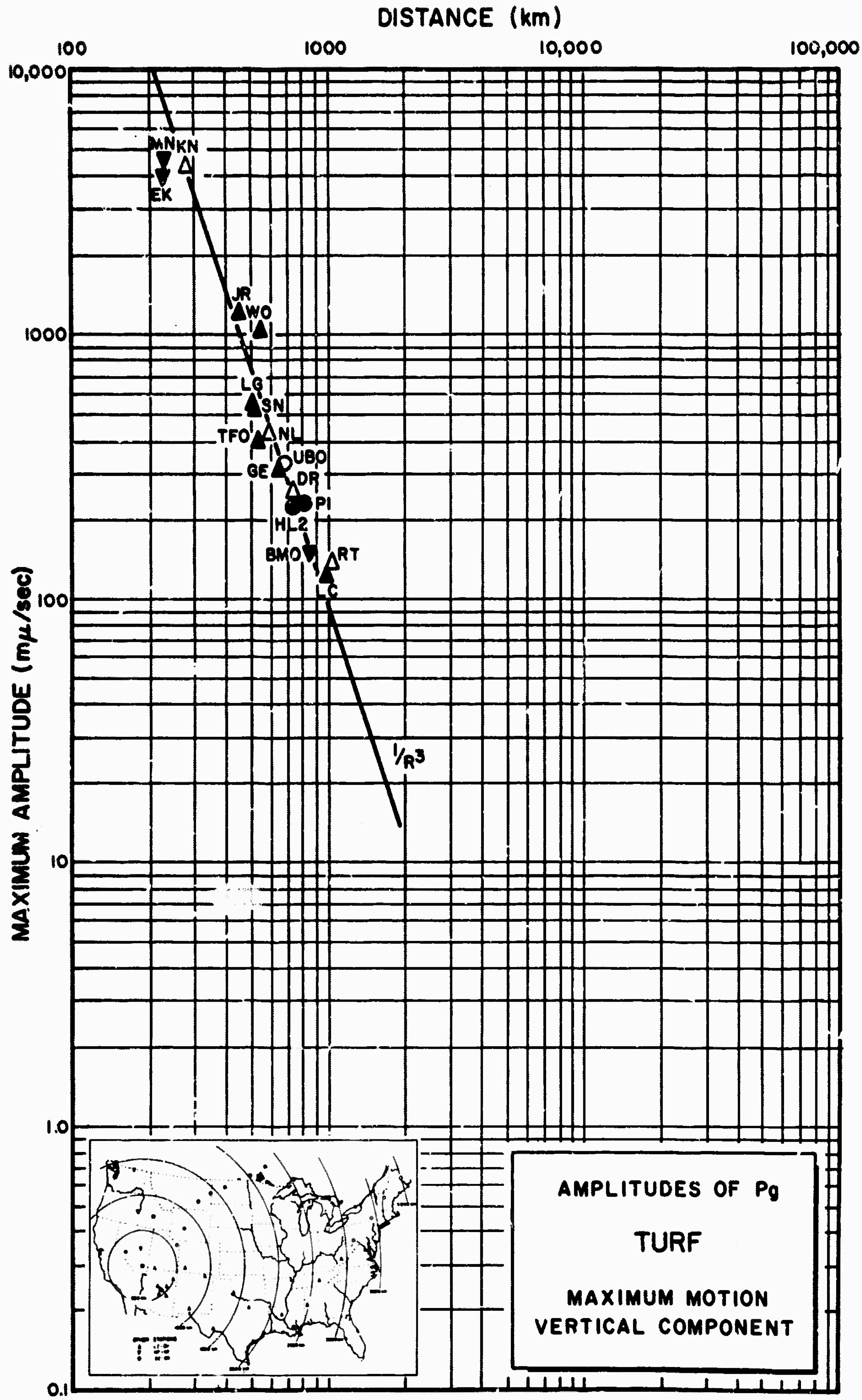

DISTANCE (km)
100
1000
10,000
100,000
10,000
1000
100
10
1.0
0.1
MAXIMUM AMPLITUDE (mμ/sec)
MN
KN
EK
JR
WO
LG
SN
TFO
NL
UBO
GE
DR
PI
HL2
BMO
RT
LC
1/R³
AMPLITUDES OF Pg
TURF
MAXIMUM MOTION
VERTICAL COMPONENT

Figure 5

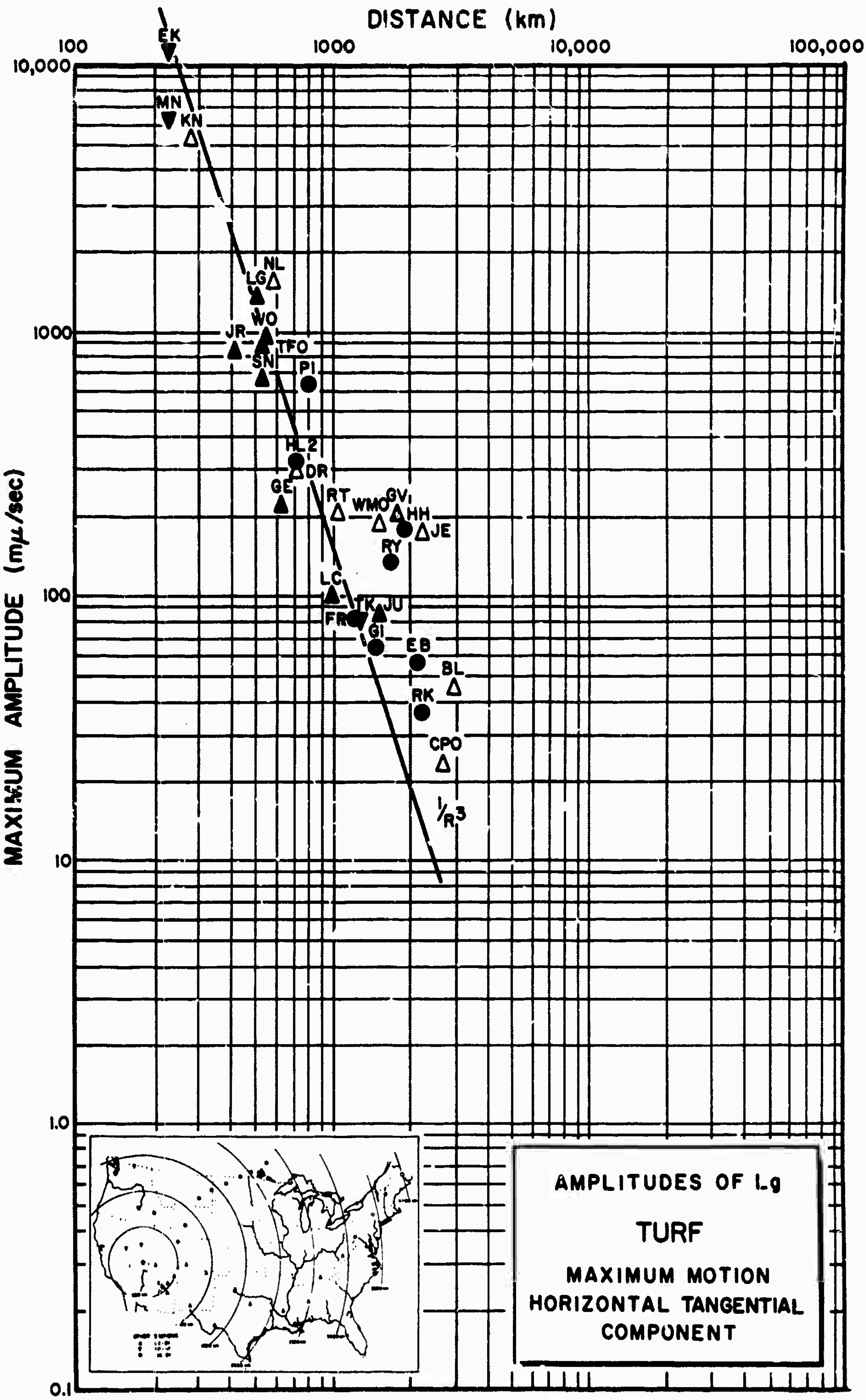

DISTANCE (km)
100
1000
10,000
100,000
10,000
1000
100
10
1.0
0.1
MAXIMUM AMPLITUDE (mμ/sec)
EK
MN
KN
NL
LG
WO
JR
TFO
SN
PI
HL2
DR
GE
RT
WMO
GV
HH
JE
RY
LC
TK
JU
FR
GI
EB
BL
RK
CPO
1/R³
AMPLITUDES OF Lg
TURF
MAXIMUM MOTION
HORIZONTAL TANGENTIAL
COMPONENT

Figure 6

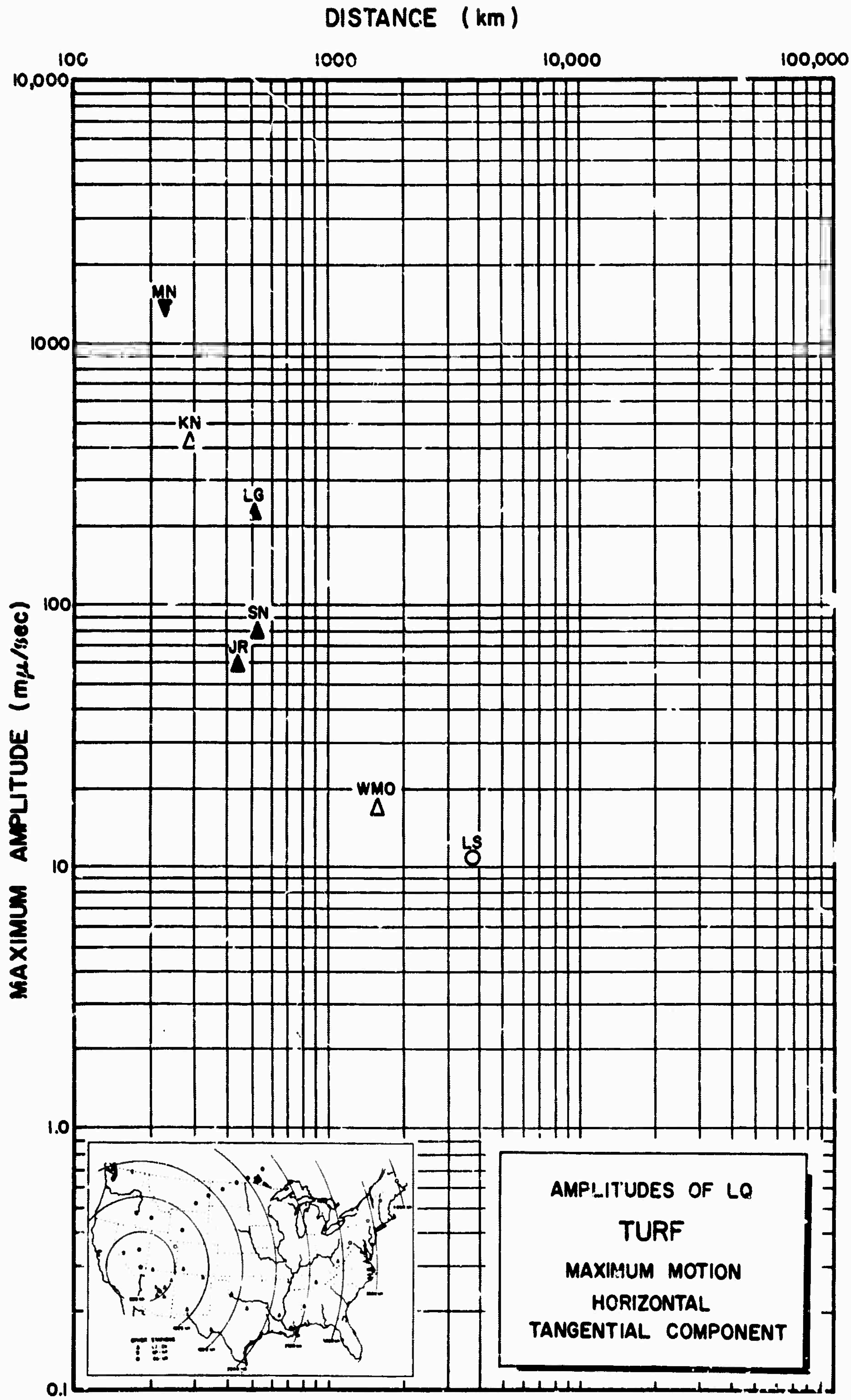

DISTANCE (km)
100
1000
10,000
100,000
10,000
1000
100
10
1.0
0.1
MAXIMUM AMPLITUDE (mμ/sec)
MN
KN
LG
SN
JR
WMO
LS
AMPLITUDES OF LQ
TURF
MAXIMUM MOTION
HORIZONTAL
TANGENTIAL COMPONENT

Figure 7

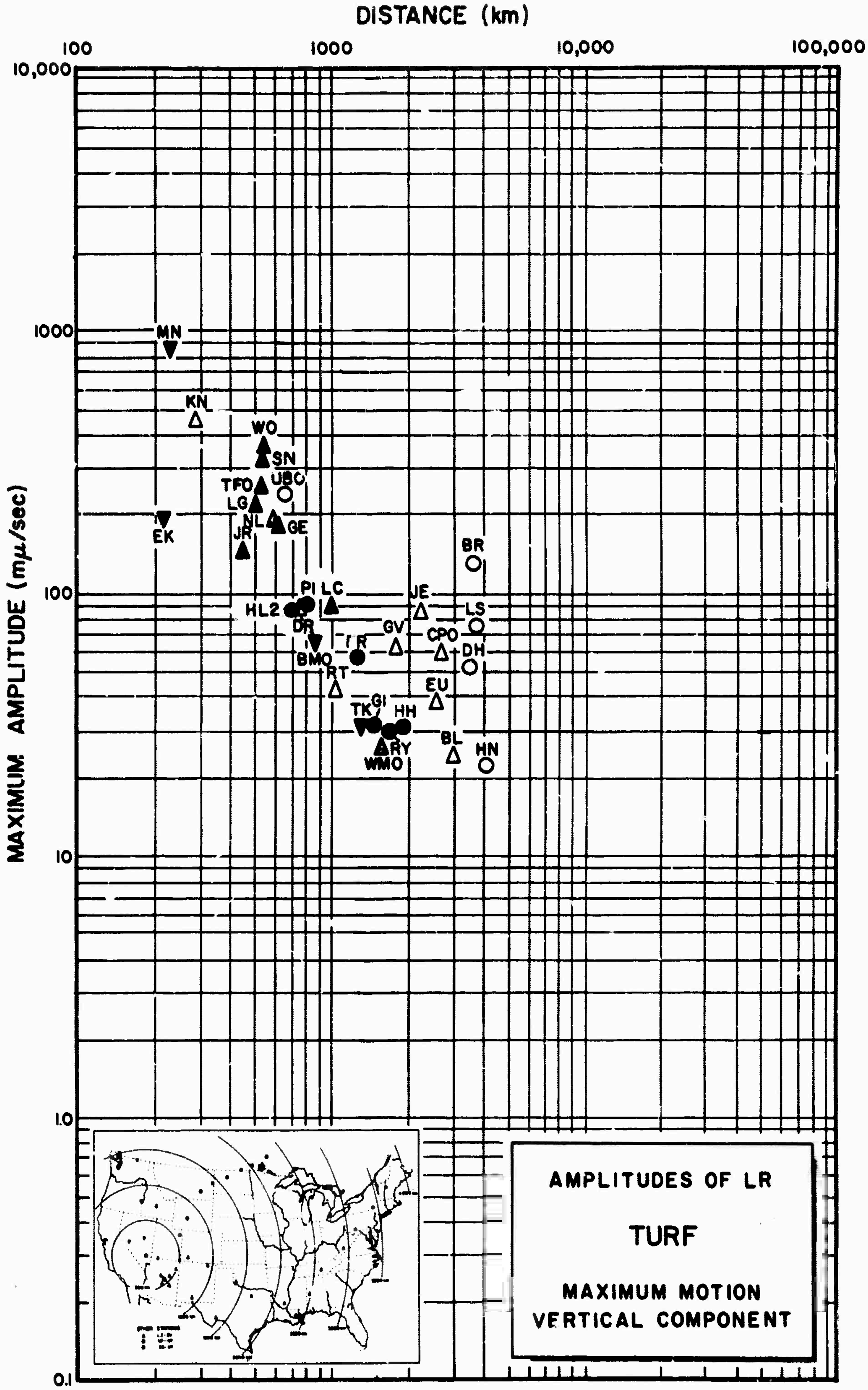

DISTANCE (km)
100
1000
10,000
100,000
10,000
1000
100
10
1.0
0.1
MAXIMUM AMPLITUDE (mμ/sec)
MN
KN
WO
SN
TFO
UBC
LG
EK
NL
GE
JR
BR
PI
LC
JE
HL2
LS
DR
GV
CPO
BMO
DH
RT
EU
TK
GI
HH
BL
HN
RY
WMO
AMPLITUDES OF LR
TURF
MAXIMUM MOTION
VERTICAL COMPONENT

Figure 8

Code	Station	Distance (km)	Geographic Latitude	Geographic Longitude	Elev. (km)	Computed Azimuth		Installed Azimuth		Large or Small SP	LP Inst.
						Epi. Sta.	Sta. Epi.	Radial	Tang.		
[illegible]-NV	Eureka, Nevada	231	39°12'32" N	115°42'37" W	1.951	7°	188°	11°	101°	L	X
MN-NV	Mina, Nevada	233	38°26'10" N	118°08'53" W	1.524	308°	127°	308°	38°	L	X
KN-UT	Kanab, Utah	287	37°01'22" N	112°49'39" W	1.737	92°	274°	95°	185°	L	X
SG-AZ	Seligman, Arizona	301	35°38'27" N	113°15'39" W	1.680	123°	305°	131°	221°	L	X
JR-AZ	Jerome, Arizona	448	34°49'32" N	111°59'25" W	1.310	124°	306°	131°	221°	L	X
LG-AZ	Long Valley, Arizona	509	34°24'28" N	111°32'45" W	1.770	125°	308°	131°	221°	S	X
TFSO	Tonto Forest Observatory, Arizona	537	34°17'12" N	111°16'03" W	1.609	125°	308°	90°	[illegible]	JM	X
SN-AZ	Sunflower, Arizona	538	33°51'49" N	111°41'34" W	0.680	131°	314°	131°	221°	L	X
KH-AZ	Kohl's Ranch, Arizona	542	34°29'00" N	111°02'03" W	2.270	122°	305°	131°	221°	L	LPZ
WO-AZ	Winslow, Arizona	551	34°52'53" N	110°37'15" W	1.590	116°	299°	131°	221°	L	X
NL-AZ	Naalini, Arizona	597	35°54'05" N	109°34'10" W	1.770	101°	285°	131°	221°	L	X
GE-AZ	Globe, Arizona	626	33°46'32" N	110°31'41" W	1.475	125°	308°	131°	221°	L	X
UBSO	Uinta Basin Observatory, Utah	665	40°19'18" N	109°34'07" W	1.475	56°	240°	90°	0°	JM	X
HL2ID	Hailey, Idaho	726	43°33'40" N	114°25'08" W	1.830	11°	192°	13°	103°	L	X
DR-CO	Durango, Colorado	733	37°27'53" N	107°47'00" W	2.225	85°	270°	90°	180°	S	X
PI-WY	Pinedale, Wyoming	810	42°27'10" N	109°32'55" W	2.170	41°	226°	46°	136°	S	X
BMSO	Blue Mountain Observatory, Oregon	862	44°50'56" N	117°18'20" W	1.189	353°	173°	0°	90°	JM	X
LC-NM	Las Cruces, New Mexico	1012	32°24'08" N	106°35'58" W	1.585	1[illegible]9°	304°	124°	214°	L	X
RT-NM	Raton, New Mexico	1042	36°43'46" N	104°21'37" W	1.951	89°	276°	96°	186°	S	X
F[illegible]-MA	Forsyth, Montana	1276	46°06'00" N	106°26'25" W	0.823	36°	222°	43°	133°	S	X
TK-WA	Tonasket, Washington	1325	48°47'38" N	[illegible]19°35'1[illegible]" W	0.549	349°	166°	347°	77°	L	X
GI-MA	Glendive, Montana	1481	47°11'34" N	104°13'10" W	0.732	37°	225°	46°	136°	S	X
JU-TX	Juno, Texas	1591	30°06'43" N	101°04'[illegible] W	0.500	115°	303°	123°	213°	L	
WMSO	Wichita Mountains Observatory, Oklahoma	1597	34°43'05" N	98°35'21" W	0.505	95°	285°	90°	0°	JM	X
RY-ND	Ryder, North Dakota	1700	48°05'50" N	101°29'40" W	0.640		230°	50°	140°	S	X
GV-TX	Grapevine, Texas	1799	32°53'09" N	96°59'54" W	0.152	100°	291°	111°	201°	L	LPZ
HN-ND	Hannah, North Dakota	1921	48°56'53" N	98°41'33" W	0.488	41°	233°	54°	144°	S	X
EB-MT	East Braintree, Manitoba, Canada	2148	49°37'40" N	95°37'20" W	0.312	43°	237°	58°	148°	S	X
JE-LA	Jena, Louisiana	2281	31°47'05" N	92°00'55" W	0.050	98°	292°	112°	202°	L	X
RK-CN	Red Lake, Ontario, Canada	2338	50°50'20" N	93°40'20" W	0.366	42°	238°	58°	148°	S	X
EU-AL	Eutaw, Alabama	2608	32°47'10" N	87°52'00" W	0.053	92°	289°	109°	199°	S	X
CPSO	Cumberland Plateau Observatory, Tennessee	2730	35°35'41" N	85°34'13" W	0.574	84°	283°	90°	0°	JM	X
BL-WV	Beckley, West Virginia	3057	37°47'56" N	81°18'36" W	0.610	78°	279°	100°	190°	S	X
FN-WV	Franklin, West Virginia	3199	38°32'58" N	79°30'47" W	0.910	76°	279°	99°	189°	S	
[illegible]-PA	Berlin, Pennsylvania	3236	39°55'27" N	78°50'41" W	0.6[illegible]2	73°	277°	97°	187°	L	X
DH-NY	Delhi, New York	3542	42°14'39" N	74°53'18" W	0.652	68°	275°	95°	185°	S	X
LS-NH	Lisbon, New Hampshire	3767	44°14'18" N	71°55'21" W	0.274	64°	273°	94°	184°	S	X
HN-ME	Houlton, Maine	4063	46°09'43" N	67°59'09" W	0.210	60°	273°	93°	183°	S	X
HW-IS	Kamuela, Hawaii	4278	19°58'49" N	155°42'20" W	0.705	255°	55°	235°	325°	L	X
MP-NT	Mould Bay, Northwest Territories, Canada	4362	76°15'08" N	119°22'1[illegible]" W	0.059	359°	176°	356°	86°	JM S	X
LP-BV	La Paz, Bolivia	7726	16°15'31" S	68°28'47" W	4.333	131°	321°	141°	231°	JM L	X
OO-NW	Oslo, Norway	8121	61°03'17" N	10°51'58" E	0.555	24°	318°	138°	228°	L	X
[illegible]G-GR	Grafenberg, Germany	9094	49°41'32" N	11°12'55" E	0.525	31°	320°	140°	230°	L	X

Recording Site Information - TURF

Appendix I (A)

Unified Magnitude: $m = \log_{10} (A/T)_{,} + B$

where

A = zero to peak ground motion in millimicrons

$= \dfrac{(mm)\ (1000)}{K}$

T = signal period in seconds

B = distance factor (see Table below)

mm = record amplitude in millimeters zero to peak

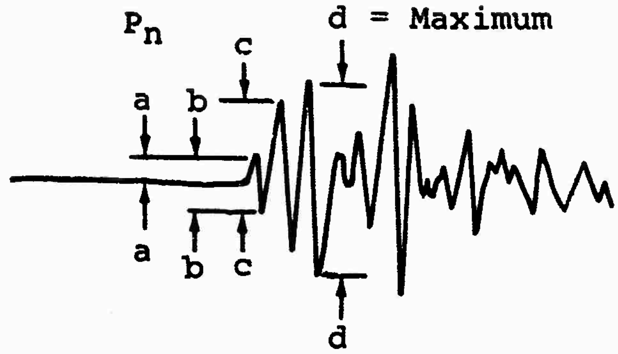
K = magnification in thousands at signal frequency

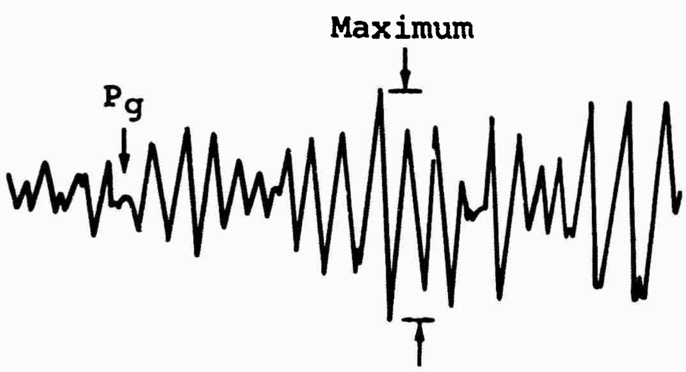
Table of Distance Factors (B) for Zero Depth

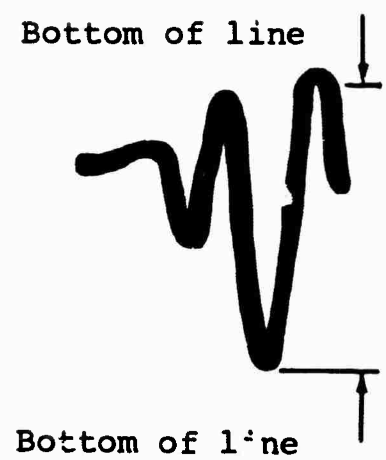
Dist (deg)	B	Dist (deg)	B	Dist (deg)	B	Dist (deg)	B
0°	-	27°	3.5	54°	3.8	80°	3.7
1	-	28	3.6	55	3.8	81	3.8
2	2.2	29	3.6	56	3.8	82	3.9
3	2.7	30	3.6	57	3.8	83	4.0
4	3.1	31	3.7	58	3.8	84	4.0
5	3.4	32	3.7	59	3.8	85	4.0
6	3.6	33	3.7	60	3.8	86	3.9
7	3.8	34	3.7	61	3.9	87	4.0
8	4.0	35	3.7	62	4.0	88	4.1
9	4.2	36	3.6	63	3.9	89	4.0
10	4.3	37	3.5	64	4.0	90	4.0
11	4.2	38	3.5	65	4.0	91	4.1
12	4.1	39	3.4	66	4.0	92	4.1
13	4.0	40	3.4	67	4.0	93	4.2
14	3.6	41	3.5	68	4.0	94	4.1
15	3.3	42	3.5	69	4.0	95	4.2
16	2.9	43	3.5	70	3.9	96	4.3
17	2.9	44	3.5	71	3.9	97	4.4
18	2.9	45	3.7	72	3.9	98	4.5
19	3.0	46	3.8	73	3.9	99	4.5
20	3.0	47	3.9	74	3.8	100	4.4
21	3.1	48	3.9	75	3.8	101	4.3
22	3.2	49	3.8	76	3.9	102	4.4
23	3.3	50	3.7	77	3.9	103	4.5
24	3.3	51	3.7	78	3.9	104	4.6
25	3.5	52	3.7	79	3.8	105	4.7
26	3.4	53	3.7				

Unified Magnitudes From P_n or P Waves

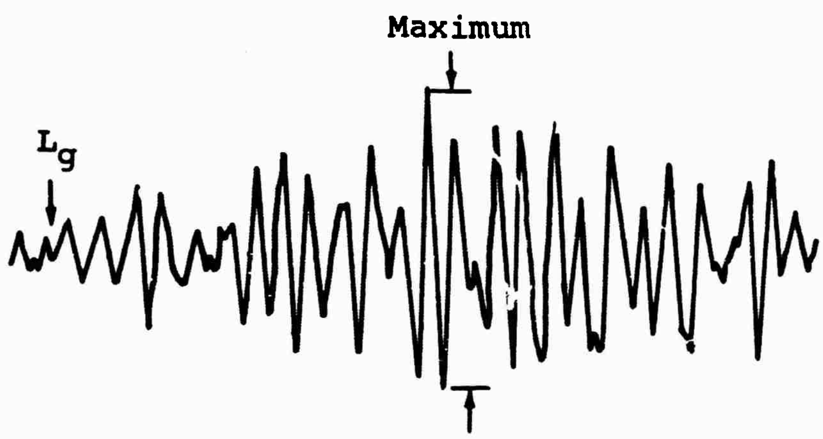
Appendix I(B)







Detail Showing Allowance For Line Width



Pick <u>time</u> of <u>Pn</u> at beginning of "a" half cycle.

Pick <u>amplitude</u> of <u>Pn</u> as maximum "$d/2$" within 2 or 3 cycles of "c".

Pick <u>amplitudes</u> of <u>Pg</u> and <u>Lg</u> at maximum of corresponding motion.

Seismic Analysis Diagram

Appendix II

FIRST MOTION CRITERIA
TECHNICAL WORKING GROUP II (TWG II)

Excerpt from Appendices to Hearings before the Special Subcommittee on Radiation and the Subcommittee on Research and Development of the Joint Committee on Atomic Energy; 86th Cong., 2d Sess.; April 19-22, 1960; on Technical Aspects of Detection and Inspection Controls of a Nuclear Weapons Test Ban; Part 2 of 2 Parts, pp 632-633:

"2. Identification of Earthquakes

A located seismic event shall be ineligible for inspection if, and only if, it fulfills one or more of the following criteria:

a. Its depth of focus is established as below 60 kilometers;

b. Its epicentral location is established to be in the deep open ocean and the event is unaccompanied by a hydroacoustic signal consistent with the seismic epicenter and origin time;

c. It is established within 48 hours to be a foreshock by the occurrence of a larger event of at least magnitude 6 whose epicenter coincides with that of the given event within the accuracy of the determination of the two epicenters. The eligibility of the second event for inspection must be determined separately.

d. The directions of clearly recorded first motions define a pattern which strongly indicates a faulting source. First motions recorded at distances between 1100 kilometers and 2500 kilometers will not be used. First motions beyond 3500 kilometers will not be used for events of magnitude smaller than 5.5. The apparent direction of first motion must also meet both the following minimum conditions to be considered to be clearly recorded:

(1) The amplitude of the half-cycle of apparent first motion is at least two (2) times as large as any half-cycle of apparent noise in the preceding few minutes, and

(2) The largest of the amplitudes of the half-cycle of apparent first motion and the two immediately following half-cycles:

(a) at epicentral distances less than 700 kilometers is twenty (20) times larger than any half-cycle of noise in the preceding few minutes;

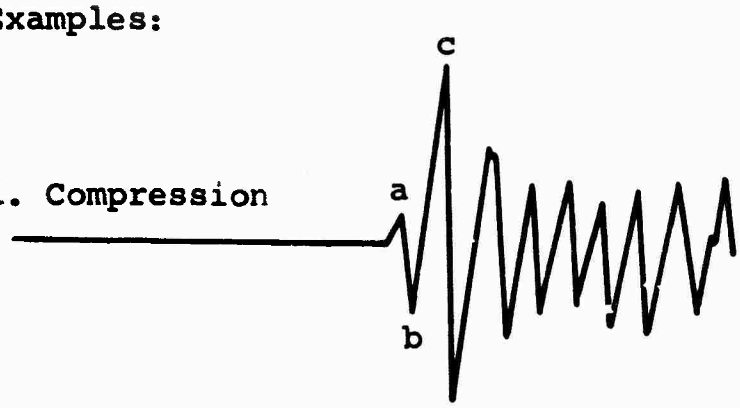
(b) at epicentral distances more than 700 kilometers is forty (40) times larger than any half-cycle of noise in the preceding few minutes.

A pattern of clearly recorded first motions strongly indicates a faulting source if the observed motions, extended backward to a small sphere about the focus, can be separated into alternate quadrants by two orthogonal great circles drawn on the small sphere, with the requirement that two opposite quadrants combined (i) contain at least 4 clearly recorded rarefactive first motions and (ii) contain not more than 15% compressions among the clearly recorded first motions."

Application of the TWG II Criteria

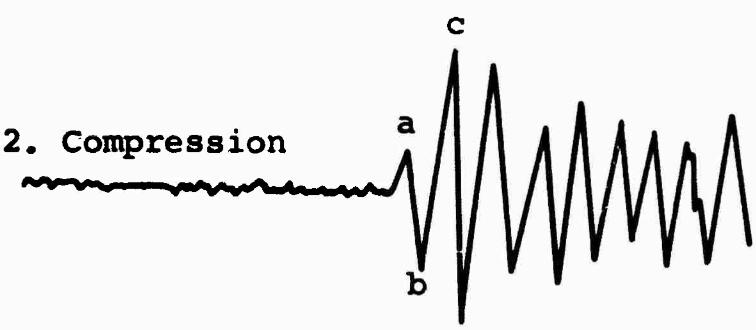
Examples:

1. Compression



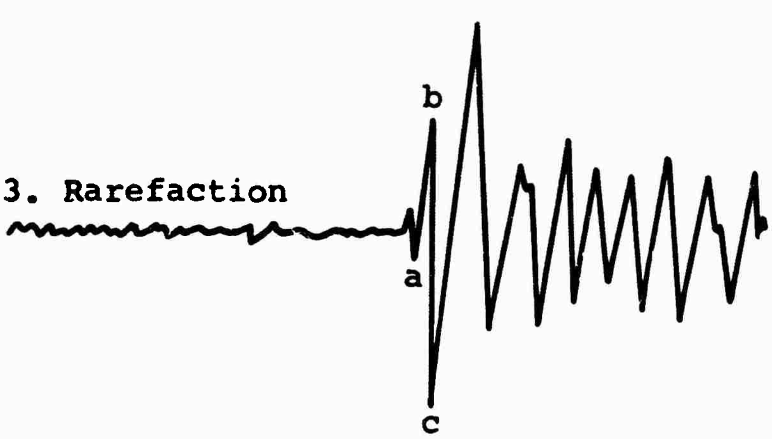
$700 < \Delta < 1100$ Km

2. Compression



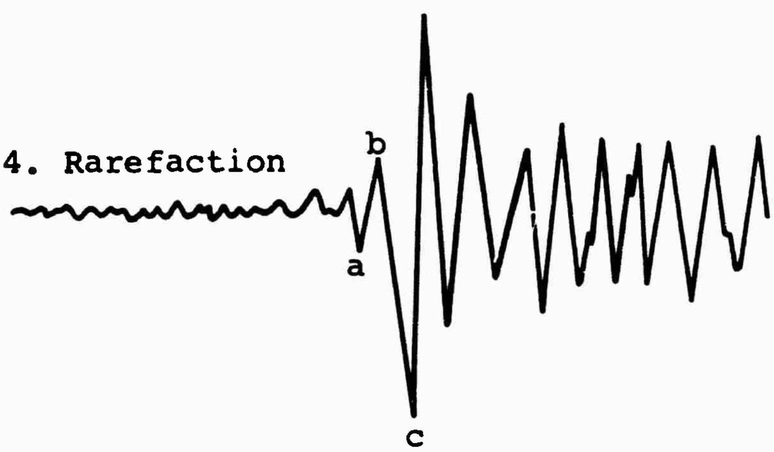
$\Delta < 700$ Km

3. Rarefaction



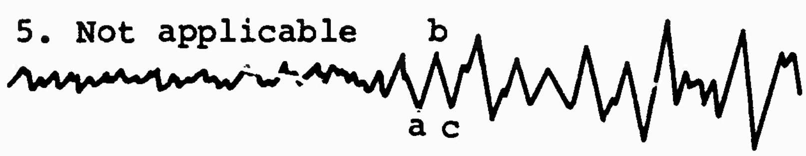
$\Delta <$ 700 Km. Example shows what may be interpreted to be earlier signal; however, motion is less than 2 times the noise level and may be interpreted as noise.

4. Rarefaction

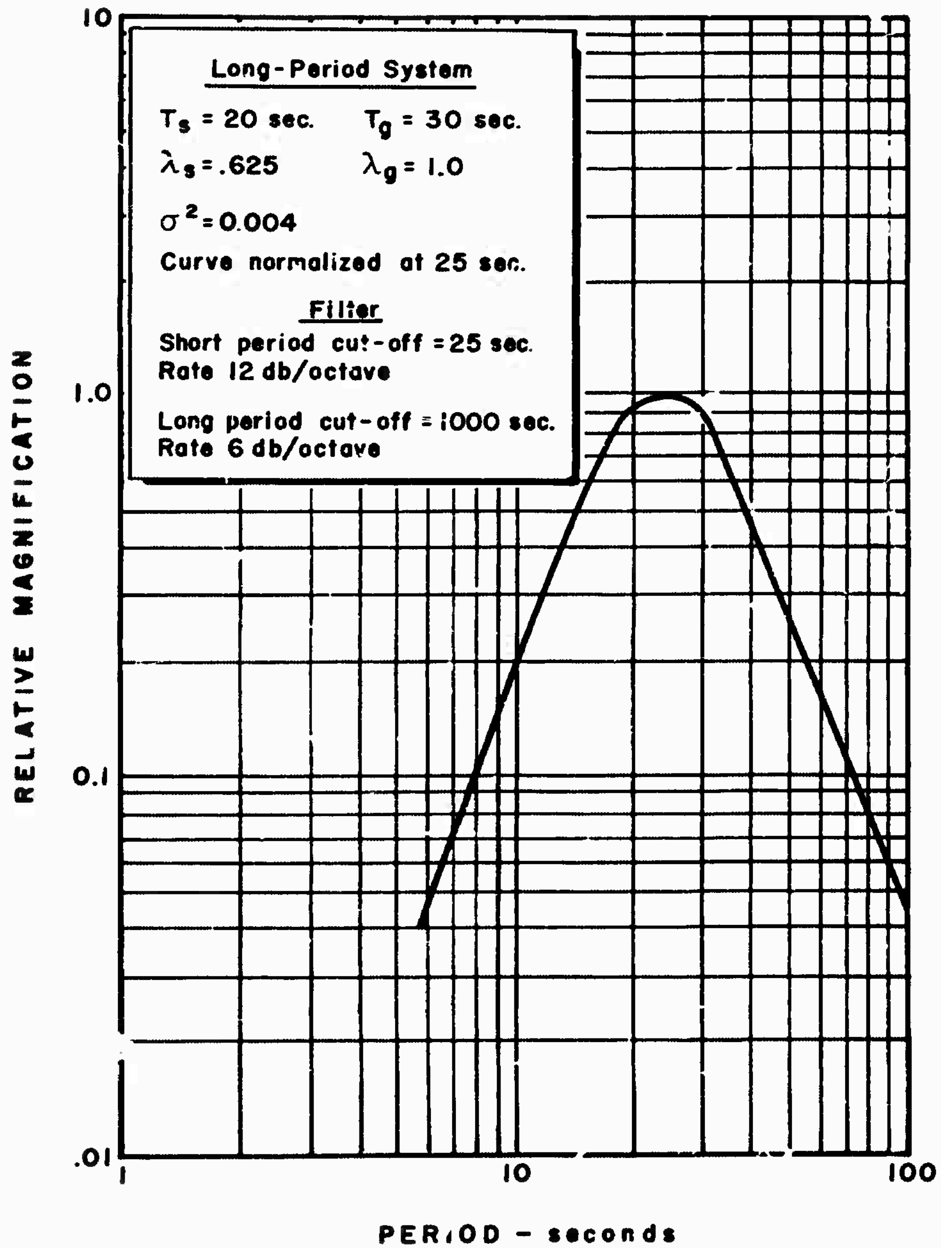


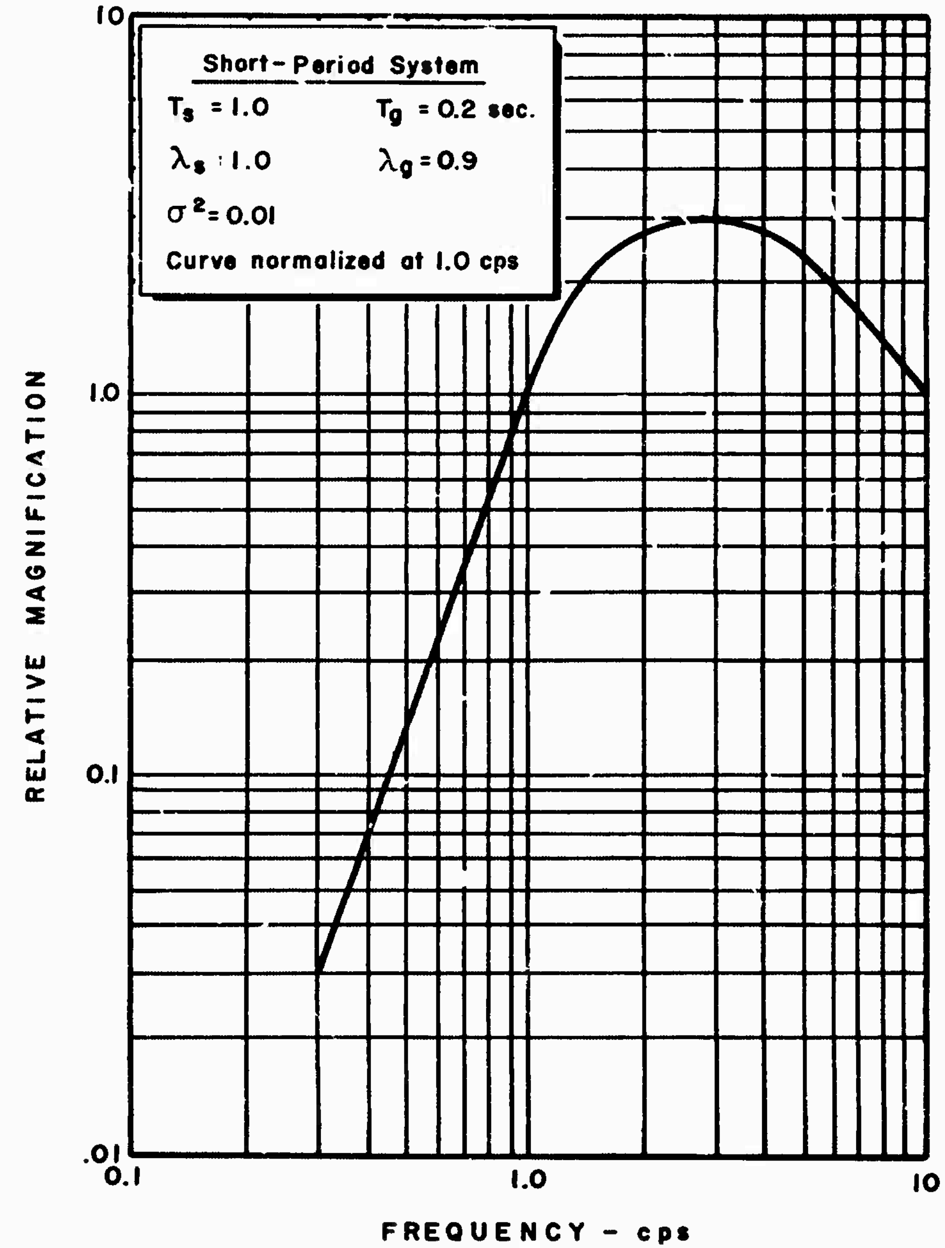
$\Delta < 700$ Km
Similar to Example 3.

5. Not applicable



$\Delta < 700$ Km
Amplitude of first
3 half-cycles is less
than 20 times noise.





LP and SP Response Curves

Unclassified

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13. ABSTRACT

An analysis of seismological data from an underground nuclear explosion as a continuing study to provide information to aid in distinguishing between earthquakes and explosions. A table of travel-times and amplitudes of P, Pg, Lg, and surface waves are included along with other unidentified phases.

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Unclassified

Security Classification

14 KEY WORDS	LINK A ROLE	LINK A WT	LINK B ROLE	LINK B WT	LINK C ROLE	LINK C WT
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Seismic Travel-Time						
Seismic Amplitude						
VELA-UNIFORM						
Nuclear Tests						

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12. SPONSORING MILITARY ACTIVITY: Enter the name of the departmental project office or laboratory sponsoring (*paying for*) the research and development. Include address.

13. ABSTRACT: Enter an abstract giving a brief and factual summary of the document indicative of the report, even though it may also appear elsewhere in the body of the technical report. If additional space is required, a continuation sheet shall be attached.

It is highly desirable that the abstract of classified reports be unclassified. Each paragraph of the abstract shall end with an indication of the military security classification of the information in the paragraph, represented as *(TS), (S), (C), or (U)*.

There is no limitation on the length of the abstract. However, the suggested length is from 150 to 225 words.

14. KEY WORDS: Key words are technically meaningful terms or short phrases that characterize a report and may be used as index entries for cataloging the report. Key words must be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location, may be used as key words but will be followed by an indication of technical context. The assignment of links, rules, and weights is optional.

GPO 886-551

Unclassified

Security Classification

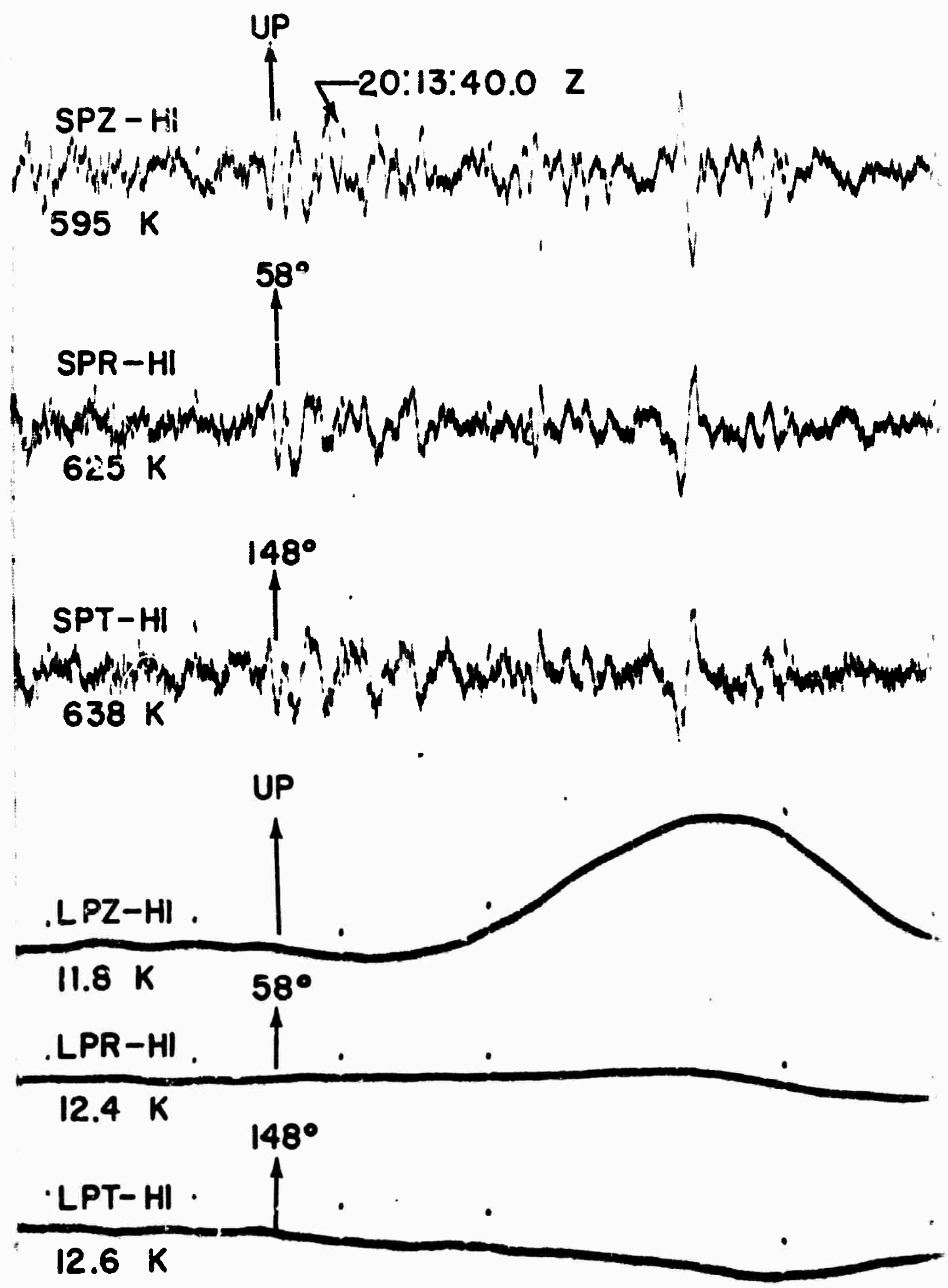
TURF

EB-MT

East Braintree, Manitoba

24 April 1964

Δ= 2148 km



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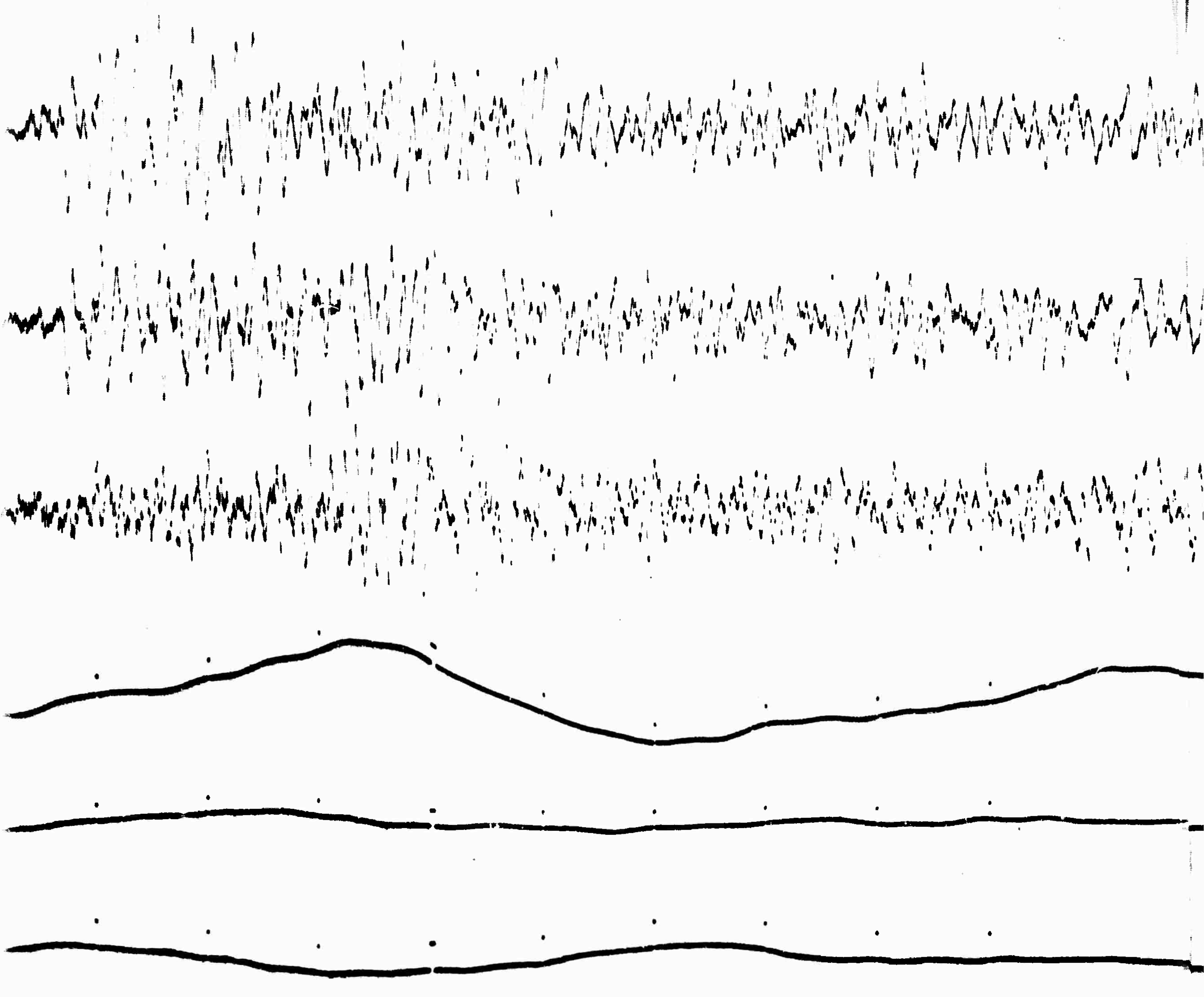

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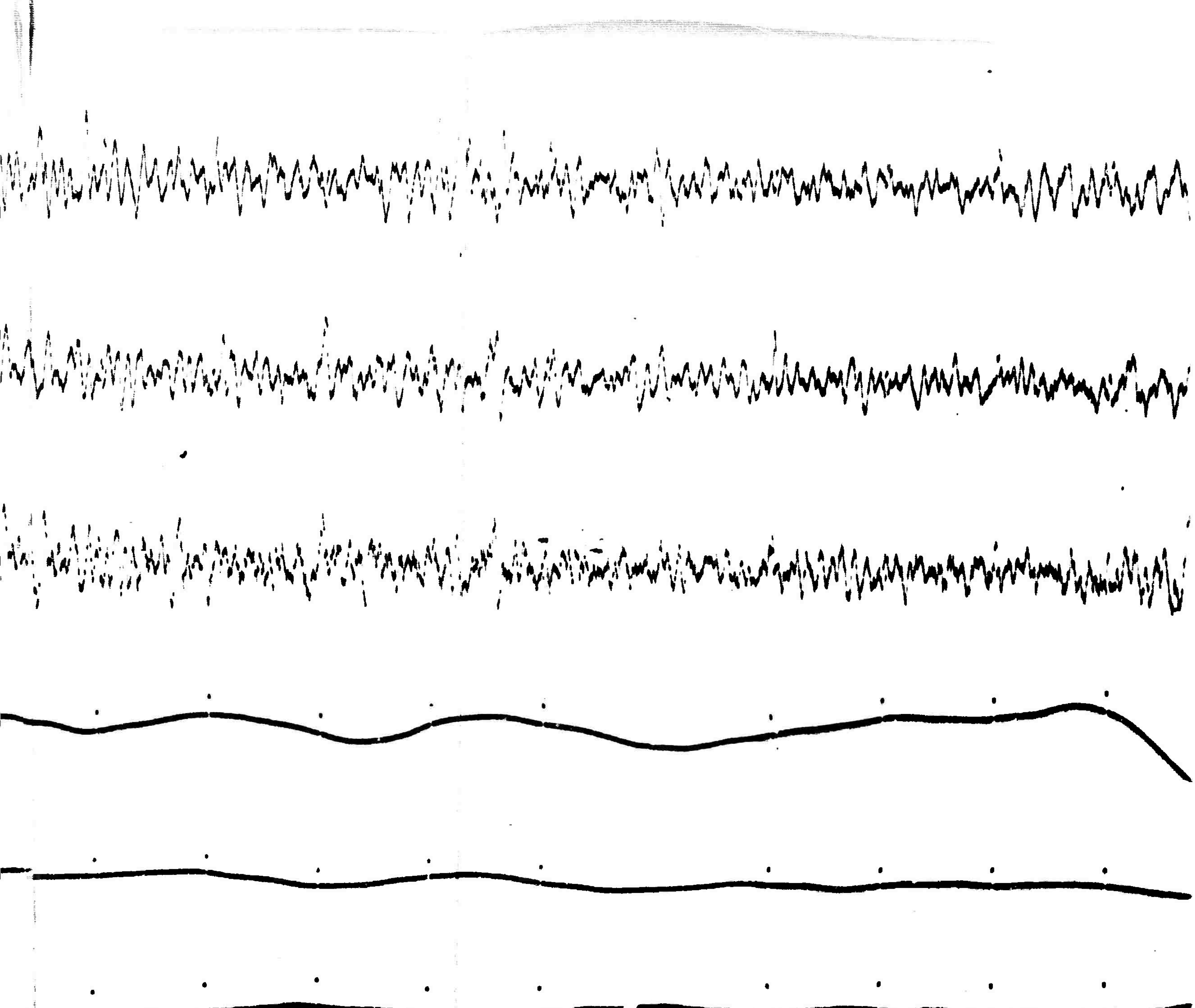

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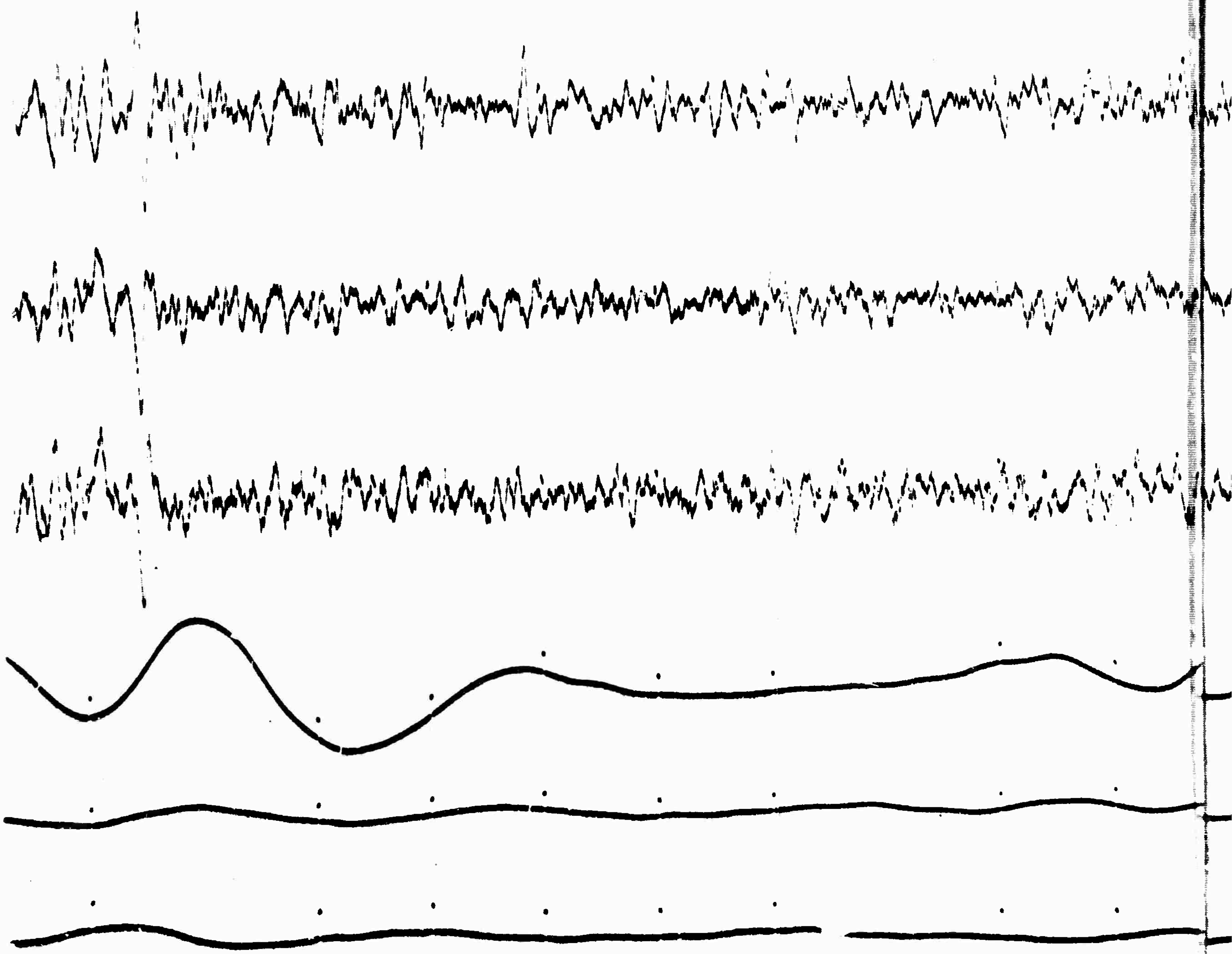

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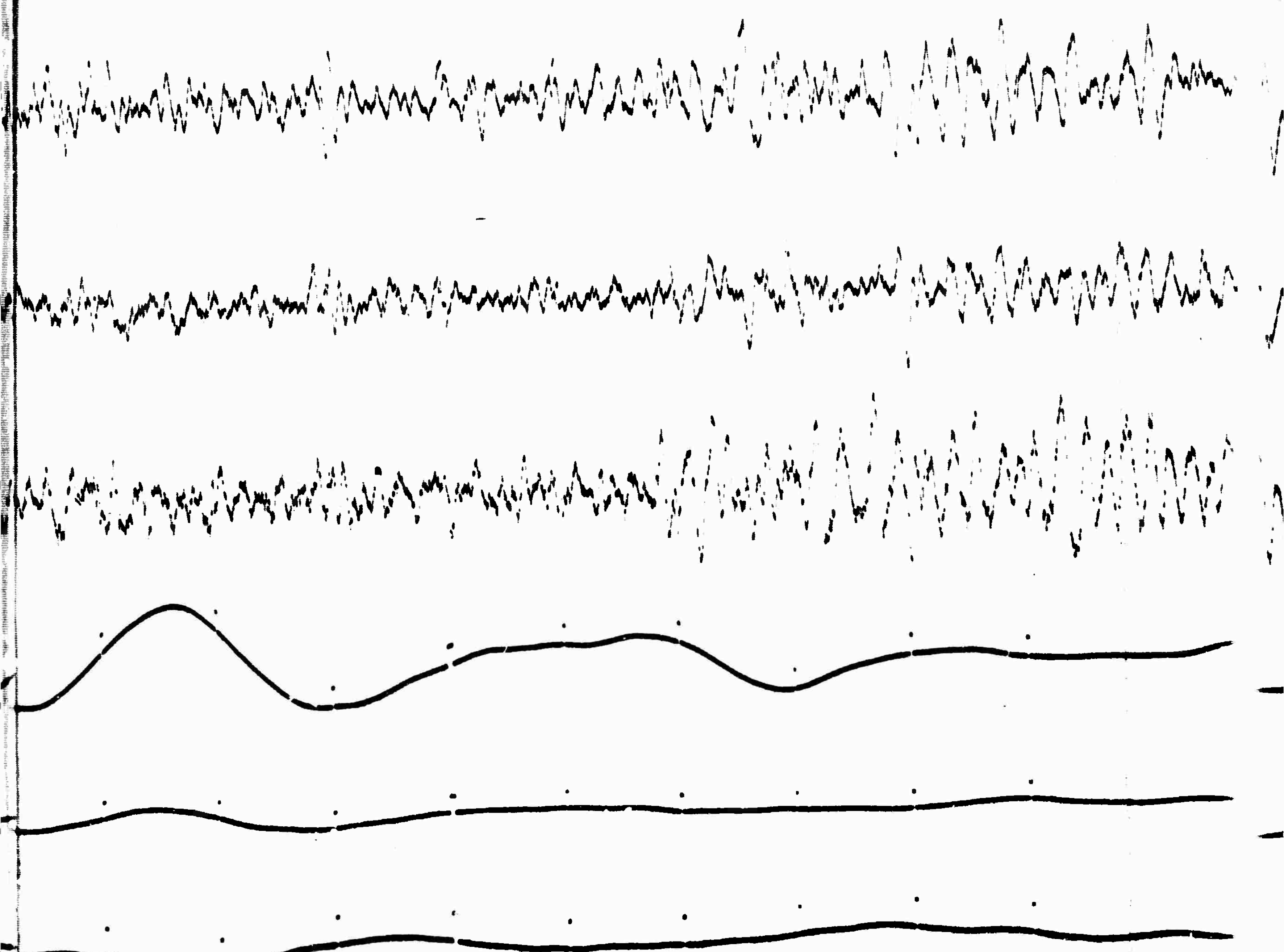

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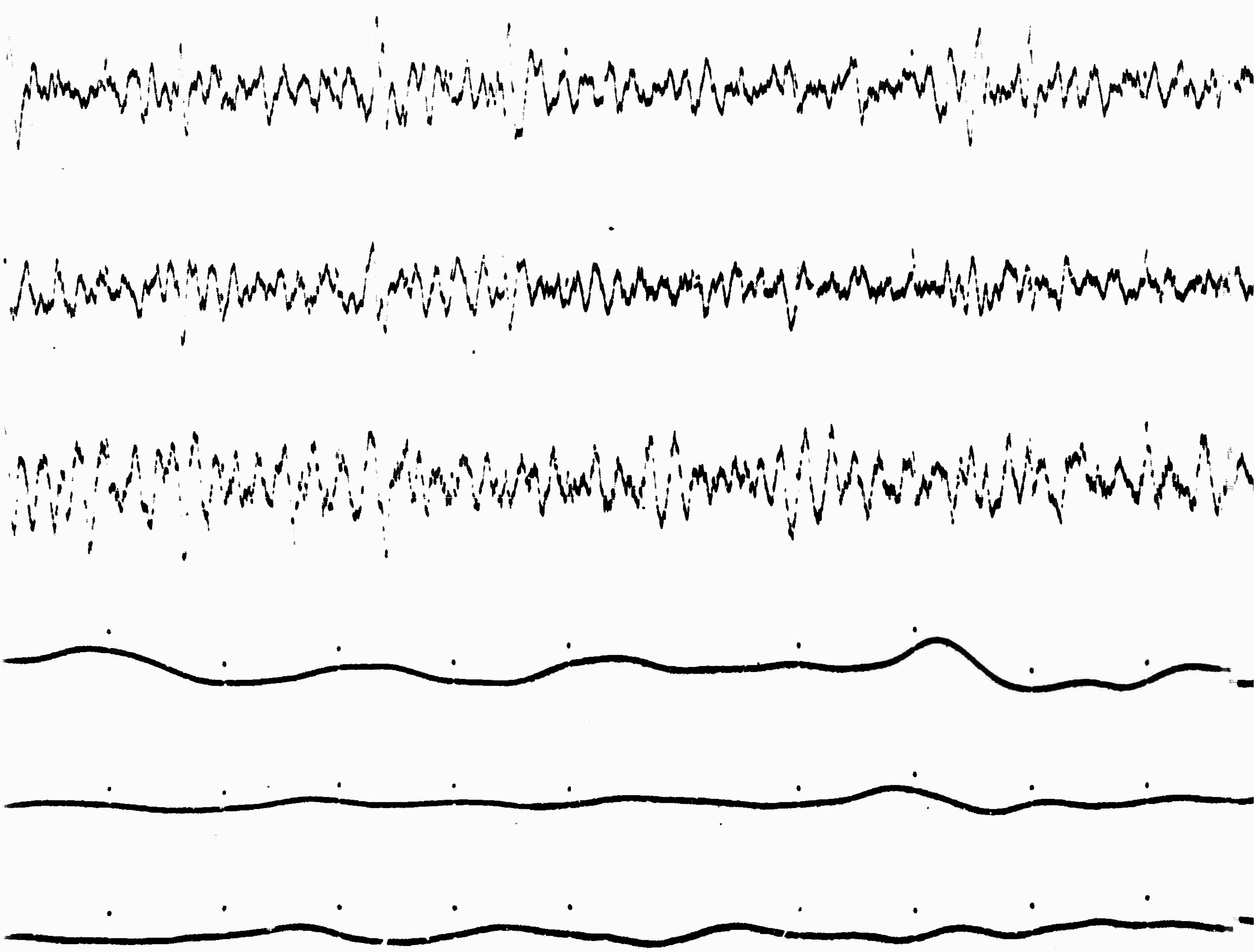

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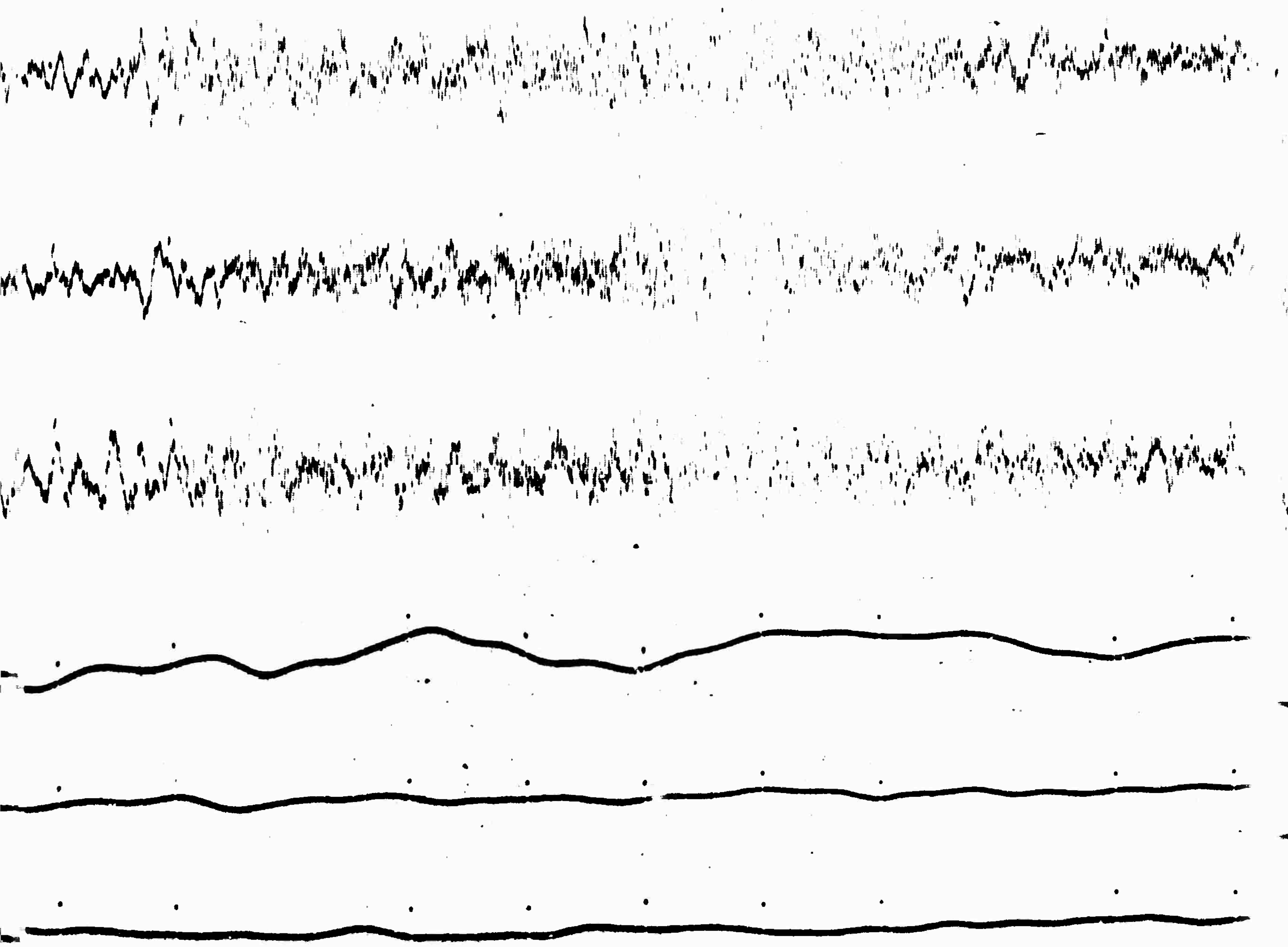

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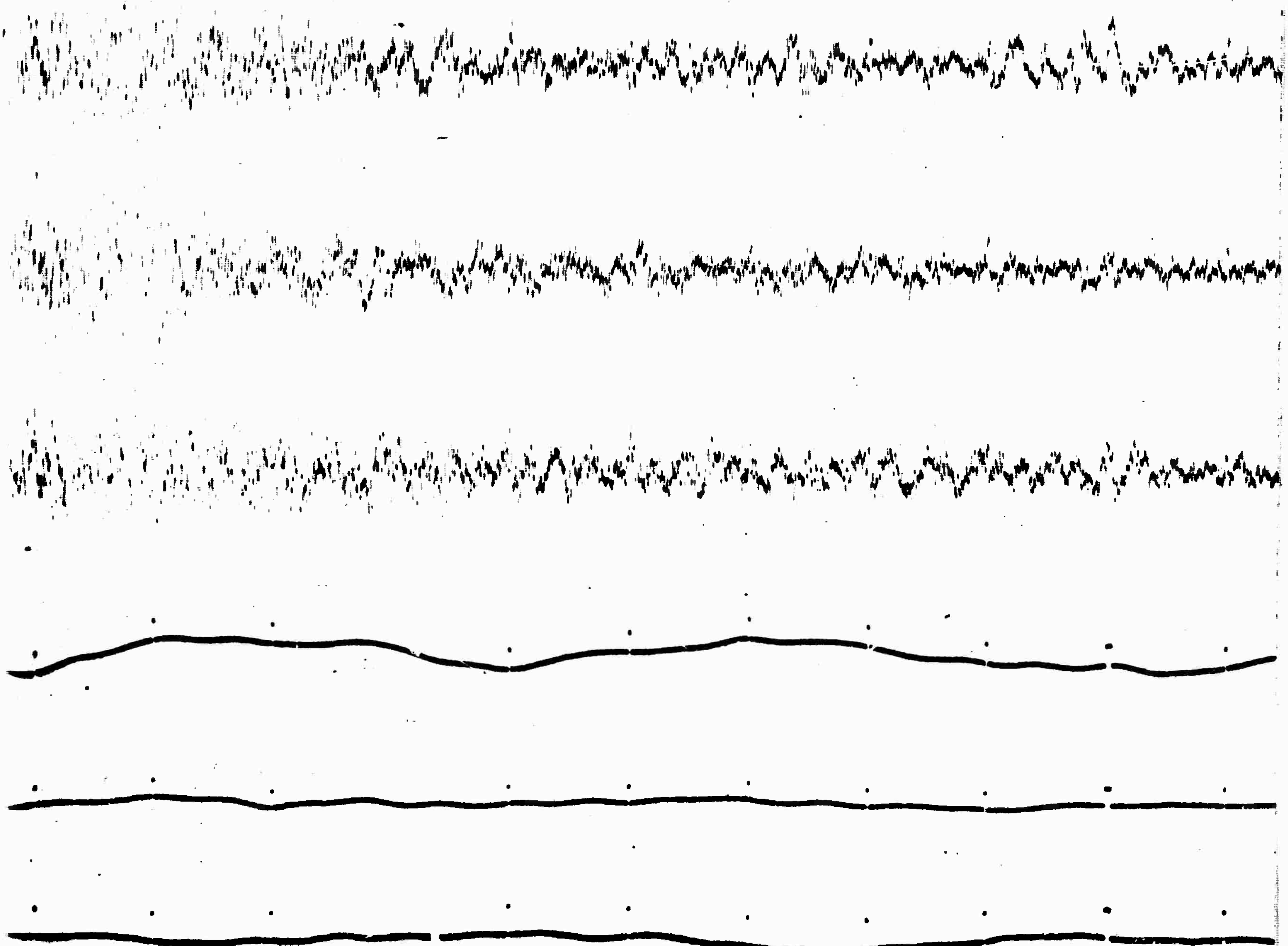


H

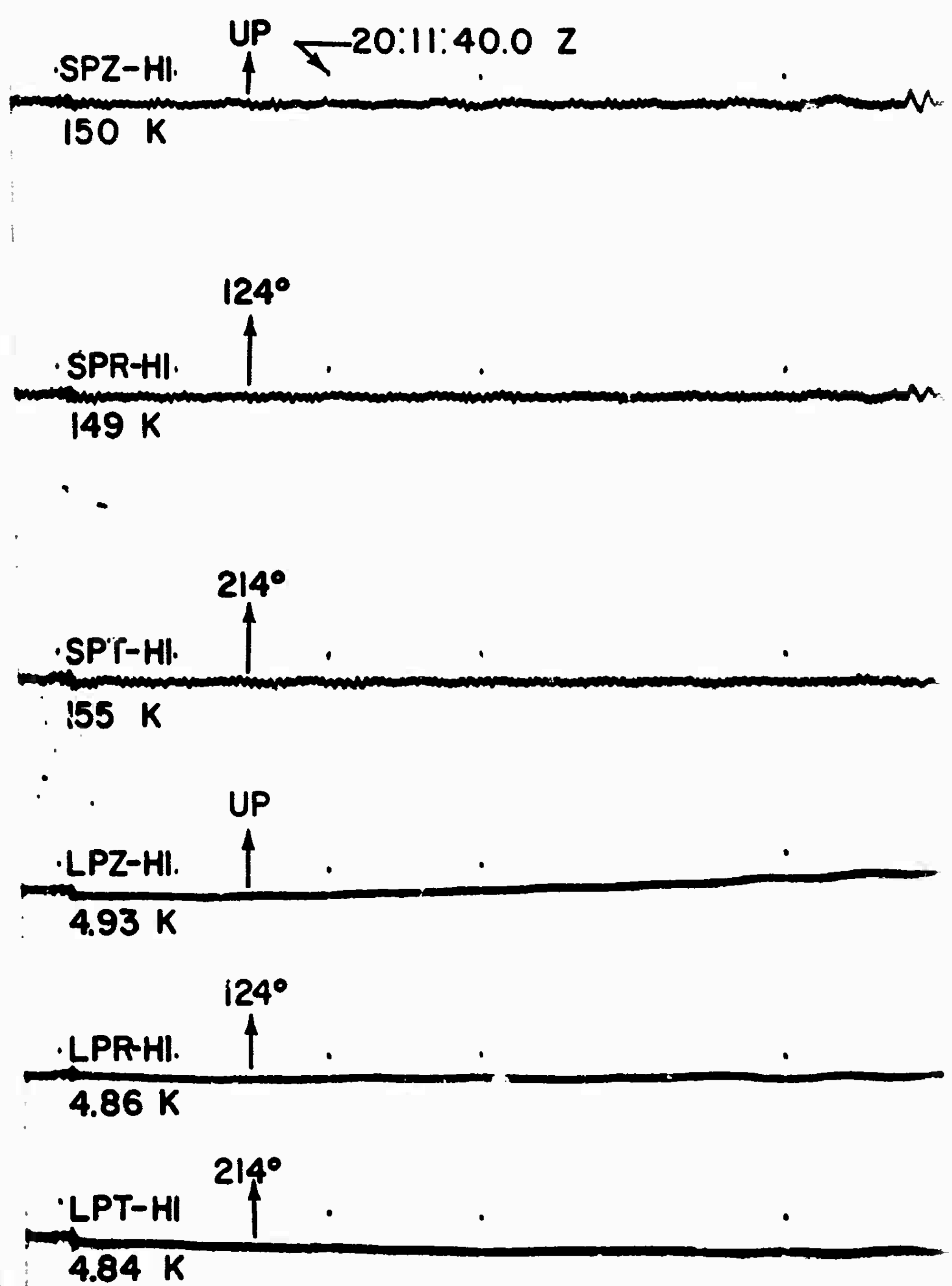
TURF

LC-NM

Las Cruces, New Mexico

24 April 1964

Δ = 1012 km



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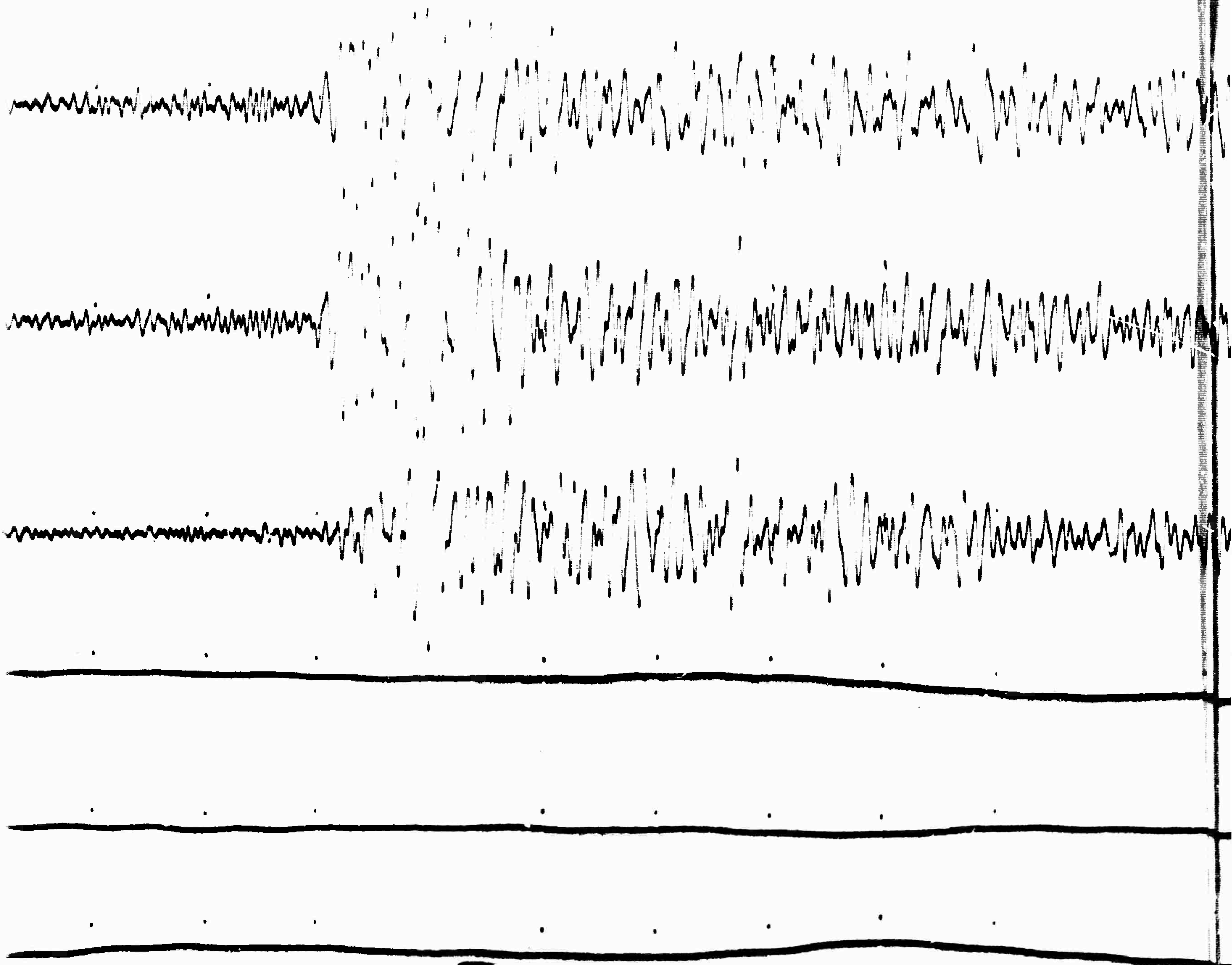

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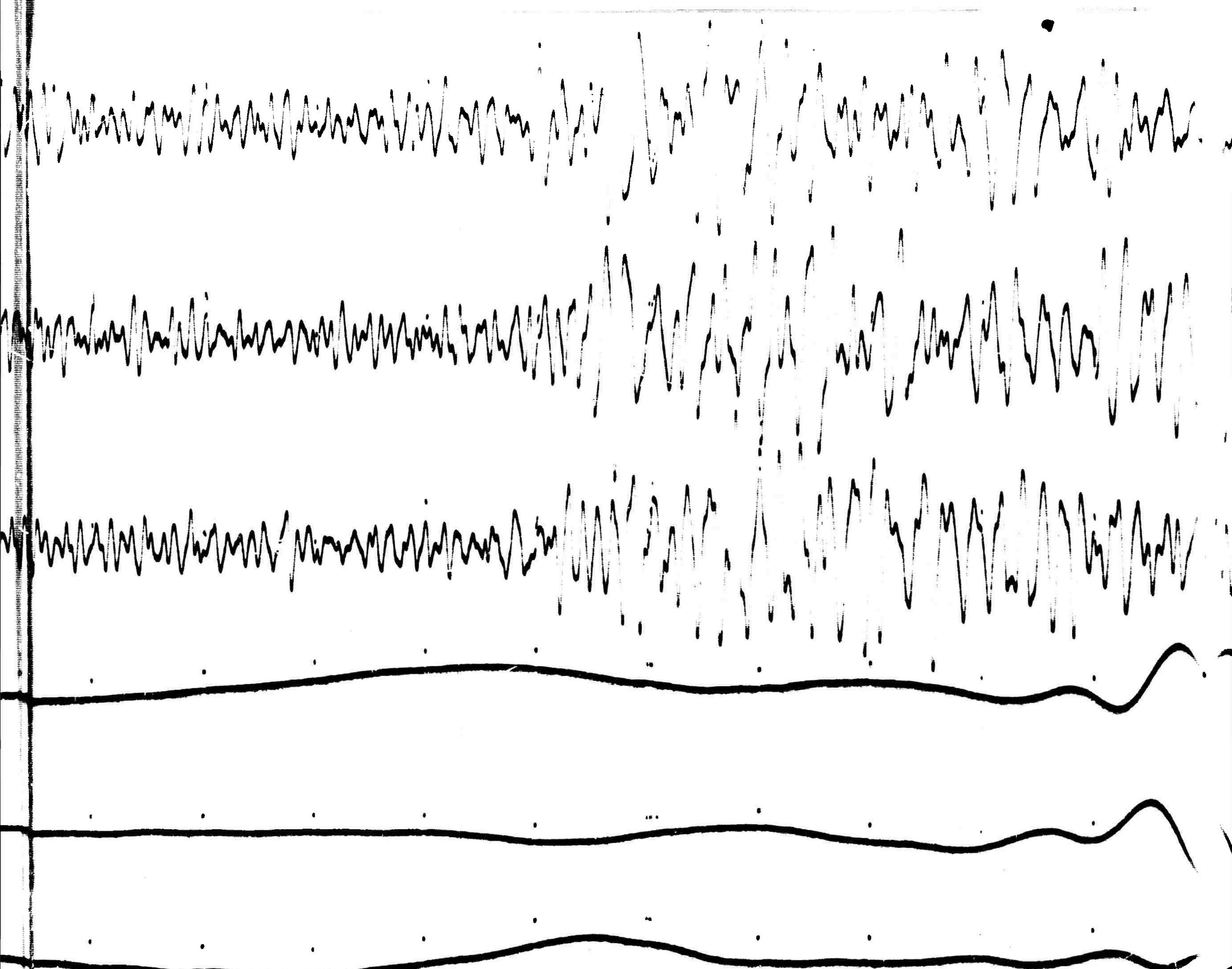

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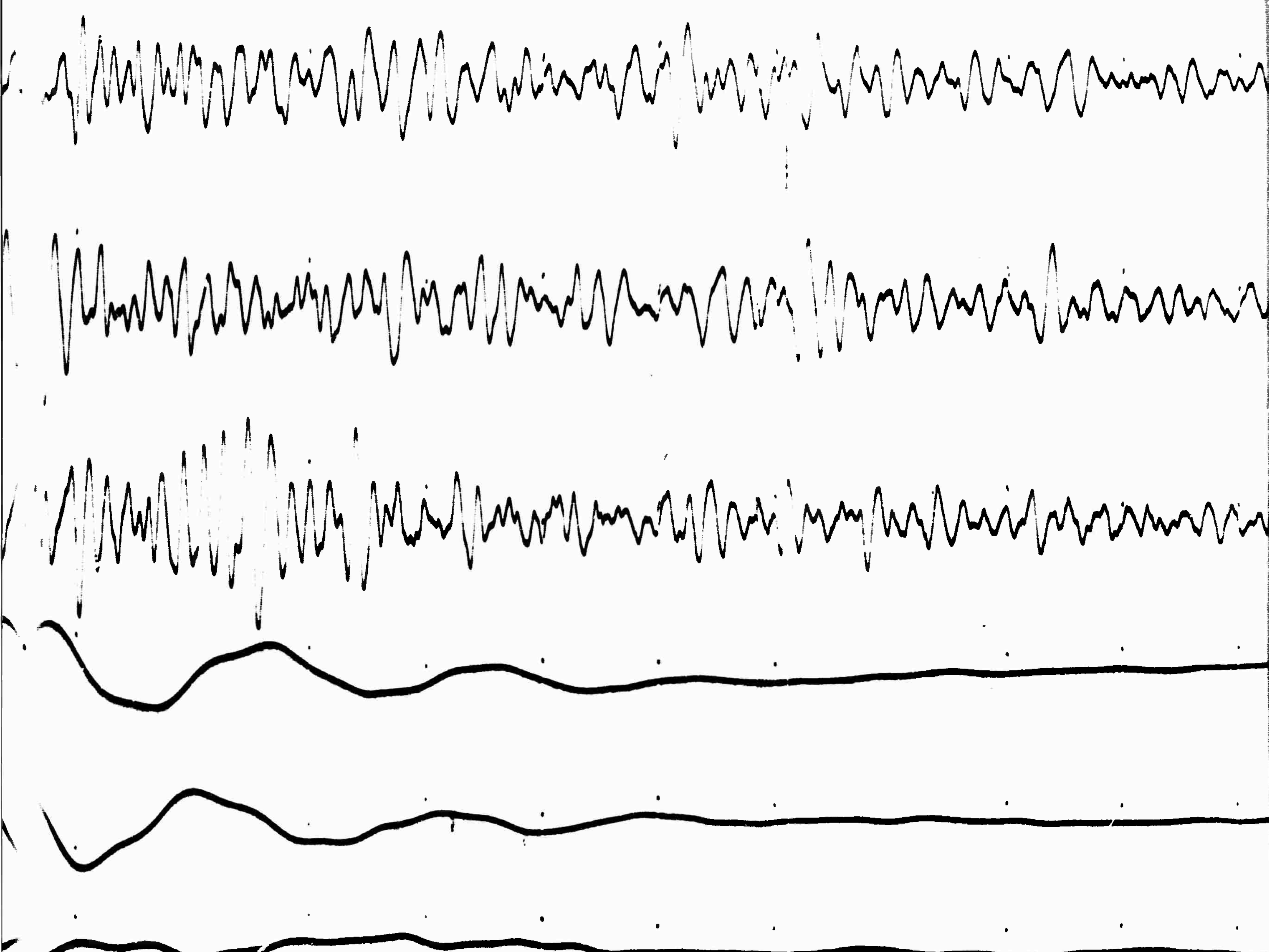

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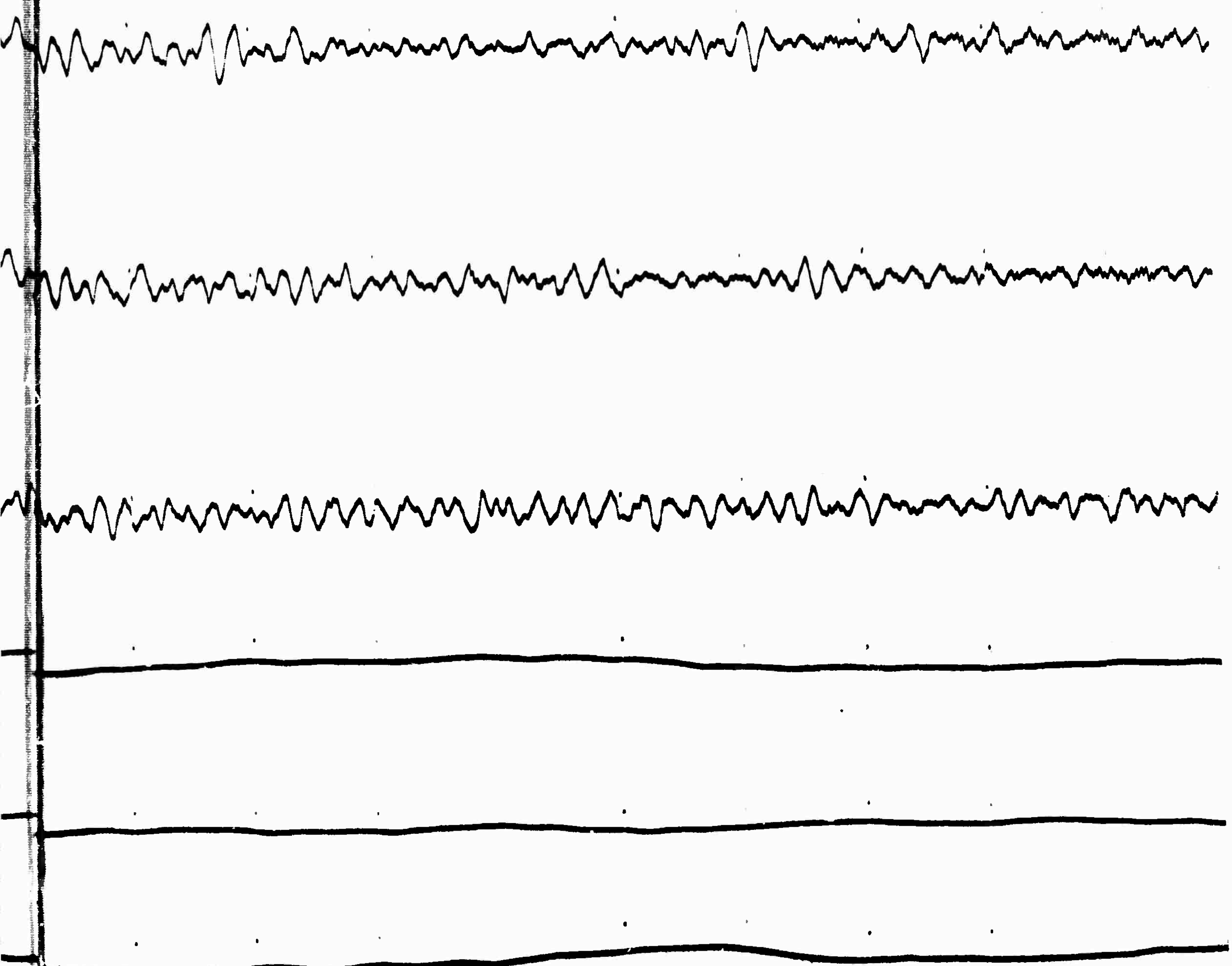


E

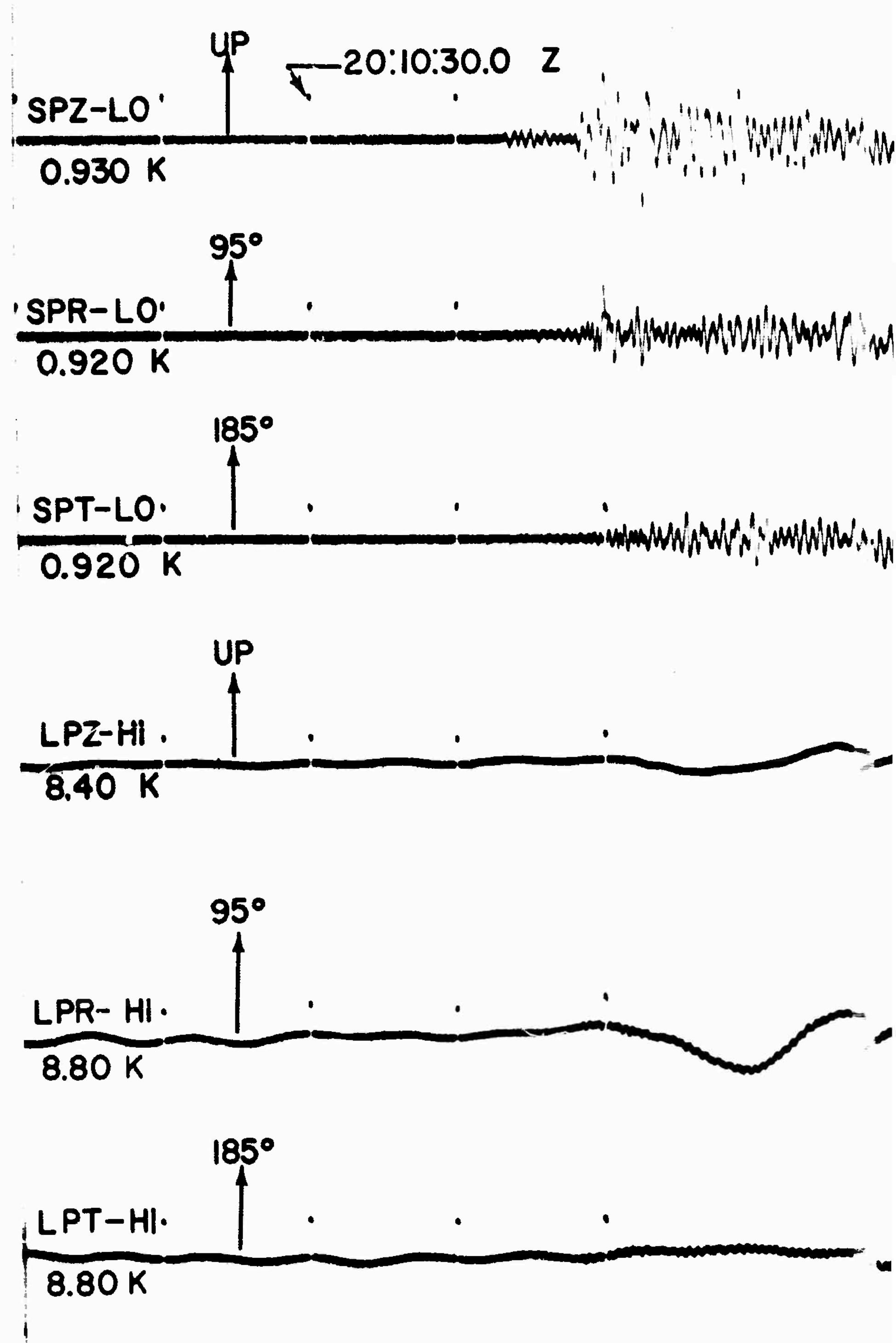
TURF

KN-UT

Kanab, Utah

24 April 1964

Δ = 287 km



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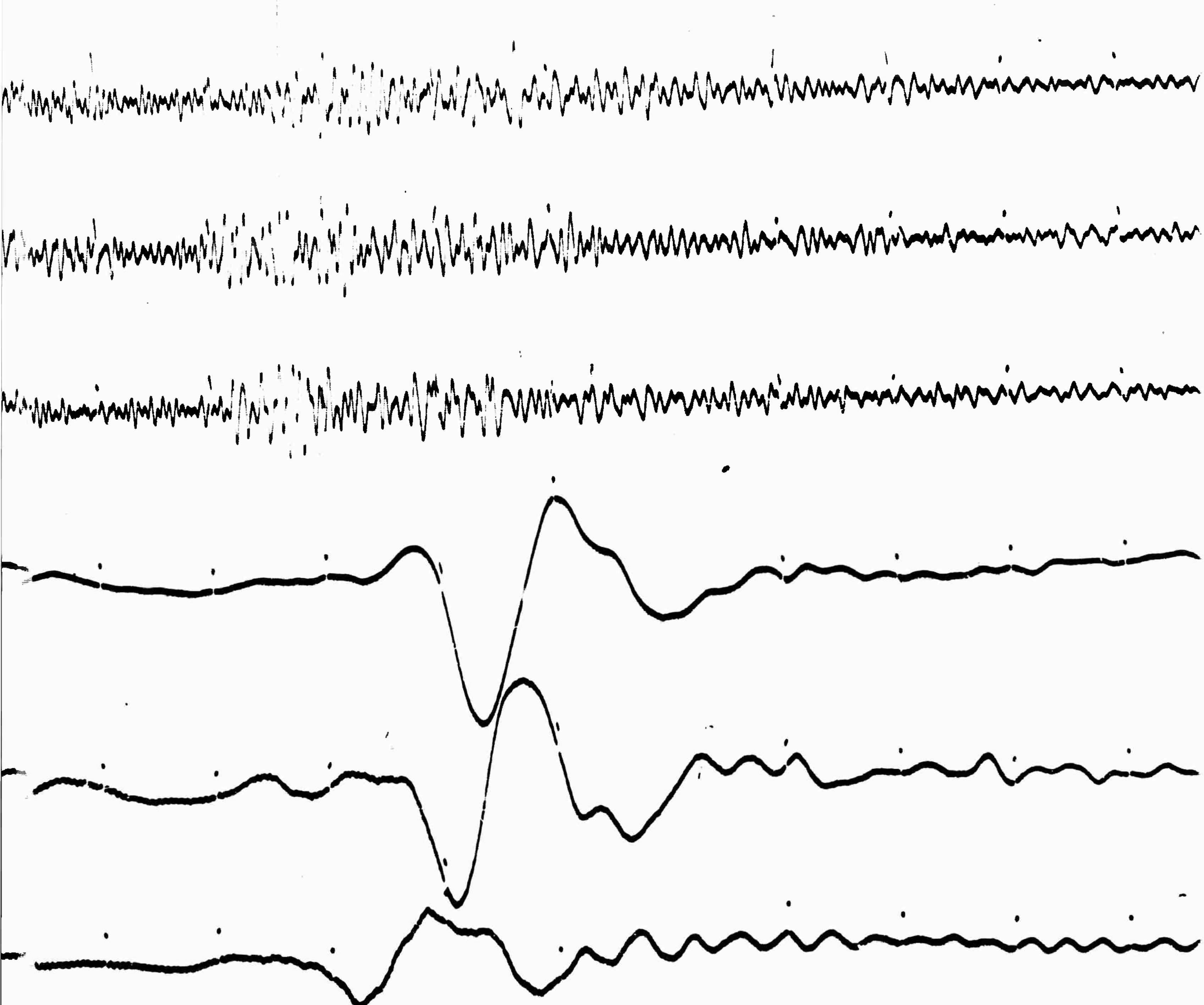

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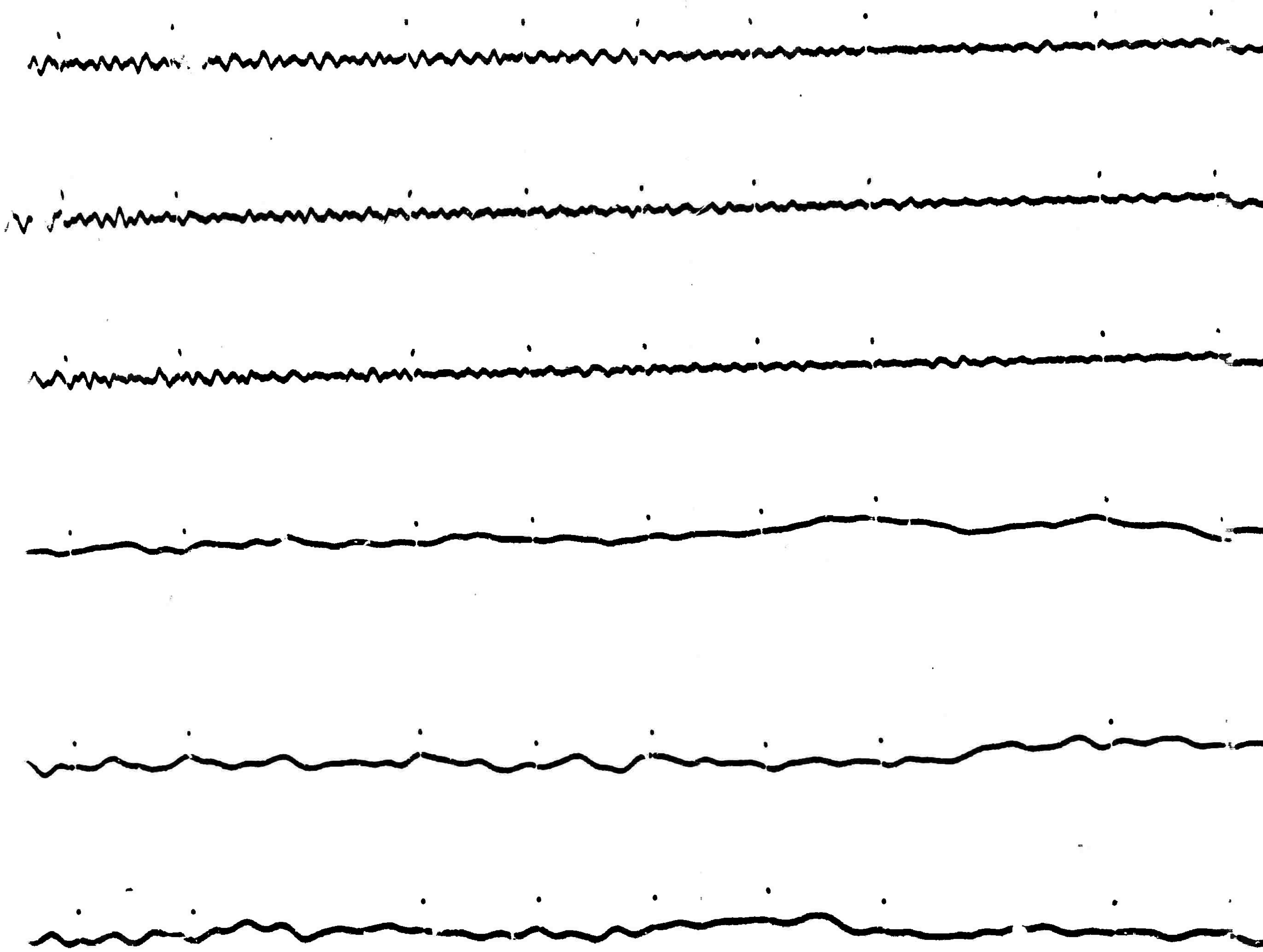

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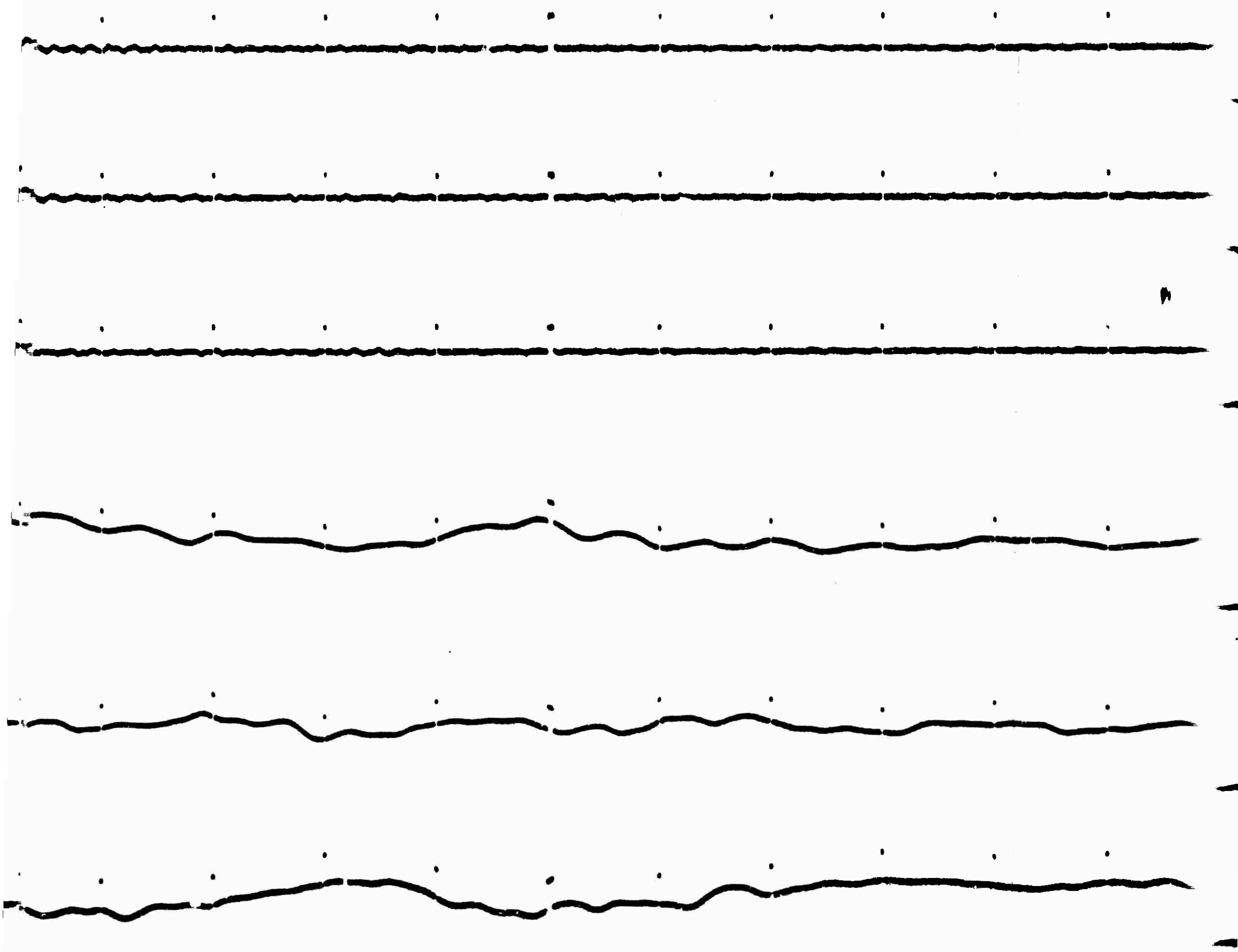

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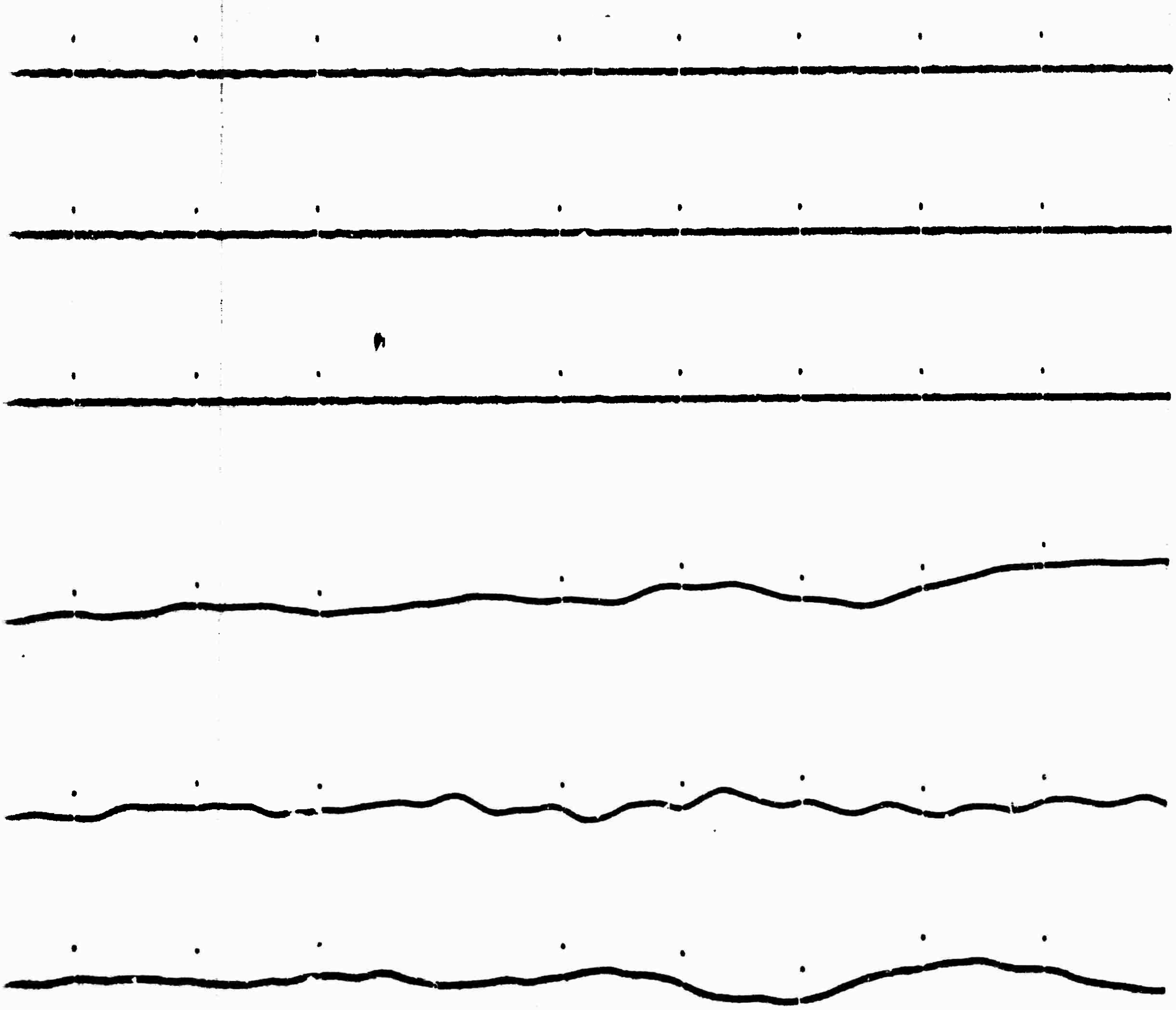


E

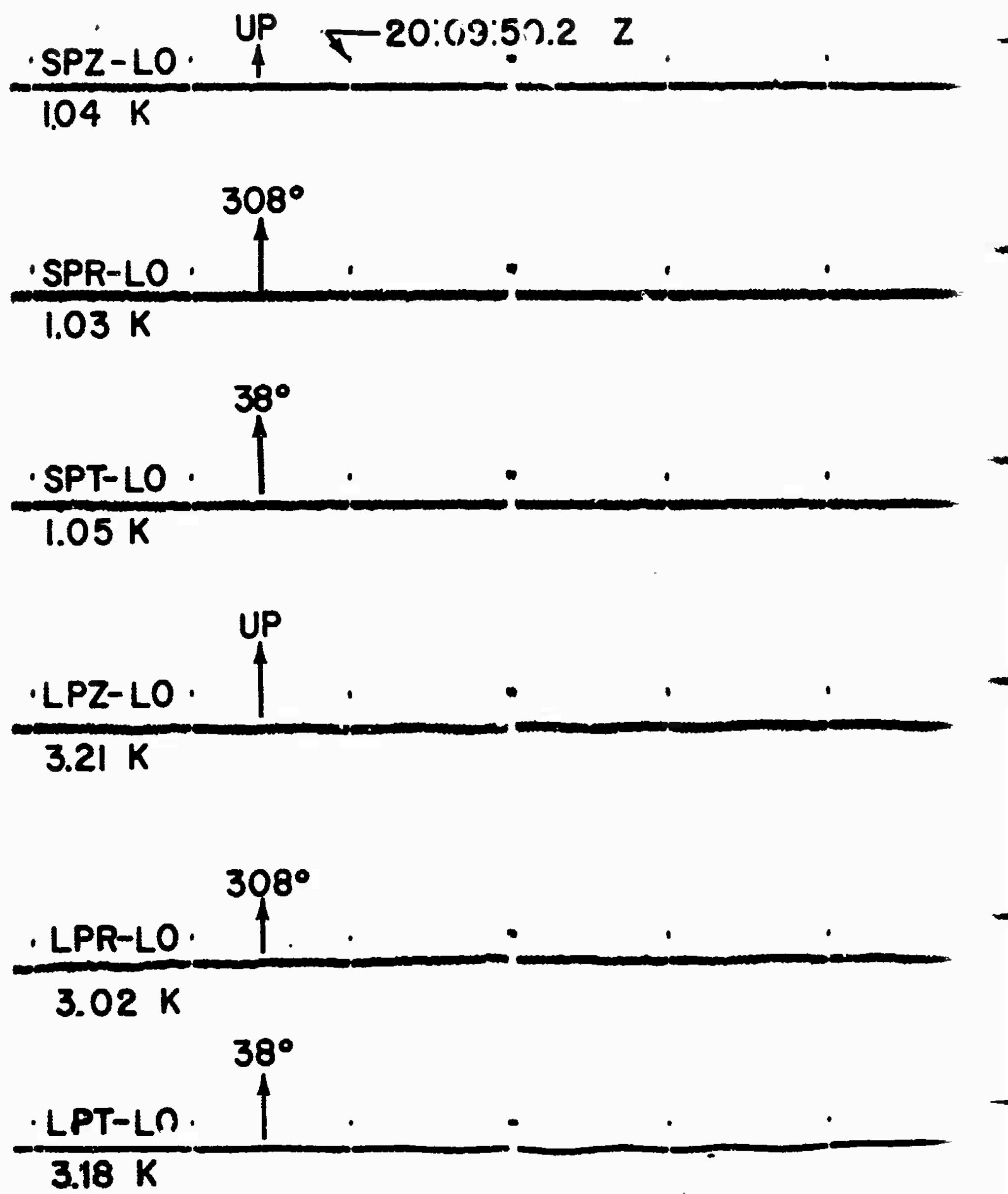
TURF

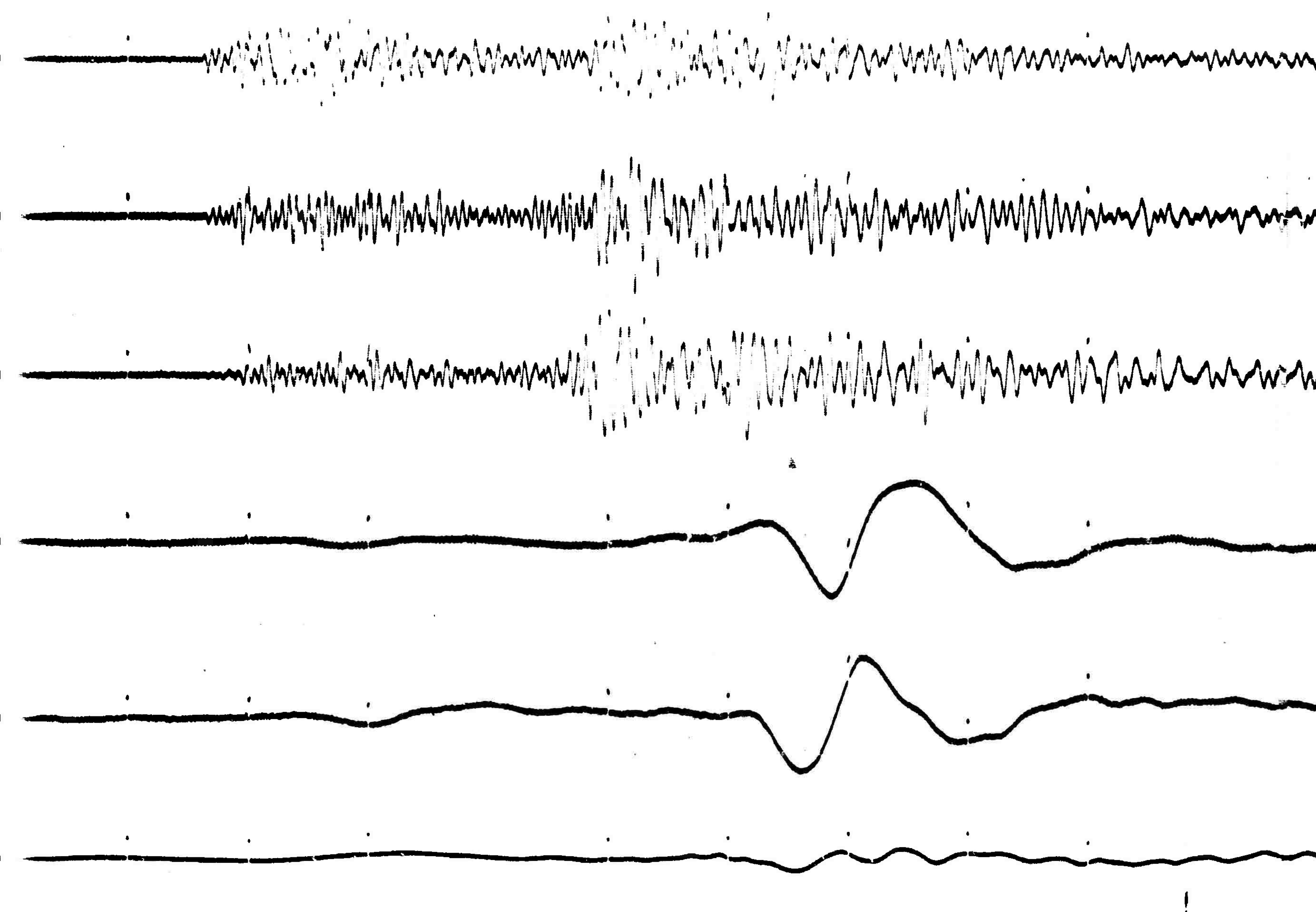
MN - NV

Mina, Nevada

24 April 1964

Δ = 233 km





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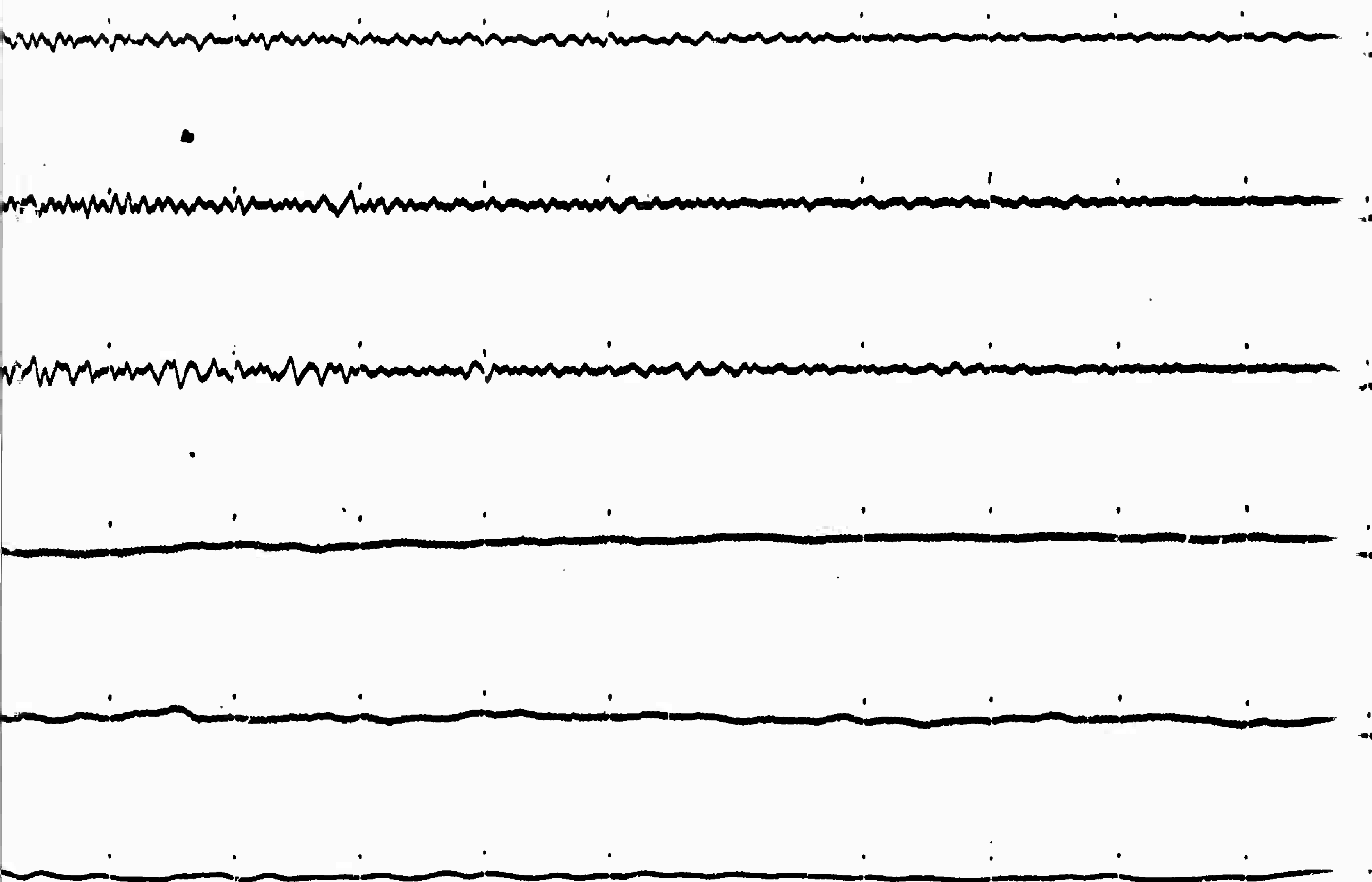

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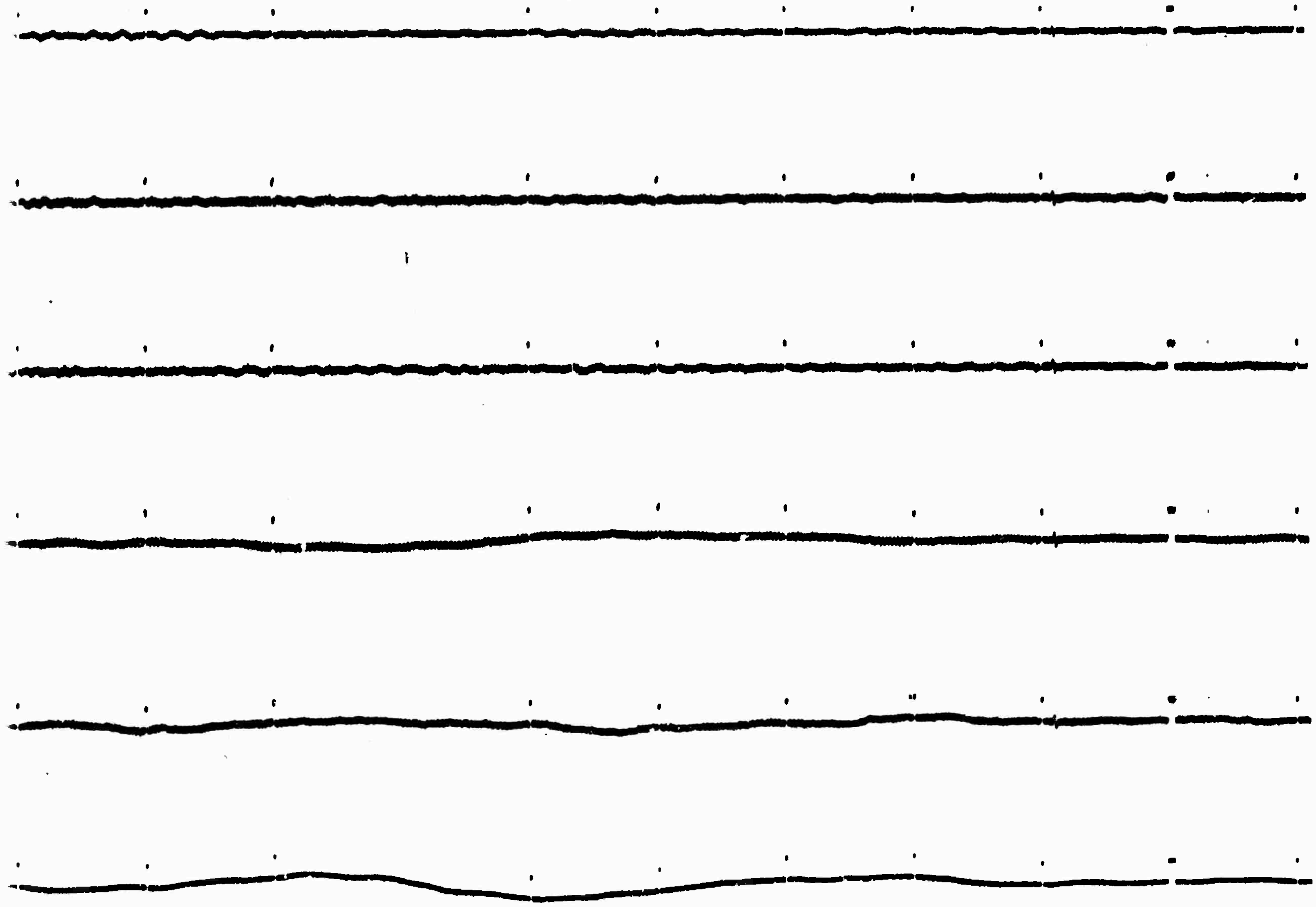

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